R E P O R T   R E S U M E S

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USE OF TECHNICAL MEDIA FOR SIMULATING ENVIRONMENTS TO PROVIDE INDIVIDUALIZED INSTRUCTION.

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AN ESTIMATE WAS OBTAINED OF THE EFFECTIVENESS WITH WHICH THE SIMULATED ENVIRONMENT MODE CAN BE USED TO TEACH CERTAIN UNITS IN EIGHT DIFFERENT SUBJECT AREAS--ART, BIOLOGY, CHEMISTRY, ELECTRONICS, ELEMENTARY PHYSICS, FRENCH, MUSIC, AND ECONOMICS. THE SPECIFIC MODE USED WAS A SPECIAL CASE OF SIMULATION IN WHICH THE USEFUL FEATURES OF VARIOUS LEARNING SITUATIONS WERE EMPHASIZED. CERTAIN ACTIVITIES WERE CONDUCTED UNDER CONTROLLED CONDITIONS WHICH WOULD HAVE BEEN DIFFICULT OR IMPOSSIBLE IN THE NATURAL (TRADITIONAL) CLASSROOM. IN ADDITION, THE SIMULATION ALLOWED PARTICIPATING STUDENTS TO PRETEND THEY WERE USING EXPENSIVE EQUIPMENT, AND PERMITTED THE COMPRESSION OF TIME (FOR EXAMPLE, BY THE USE OF TIME-LAPSE PHOTOGRAPHY). THE ELEMENTS OF THE LEARNING ENVIRONMENT WHICH WERE SIMULATED INCLUDED THE BEHAVIOR OF TEACHERS (LECTURE, DIALOGUE, COACHING, AND TESTING), A LABORATORY ENVIRONMENT, ENVIRONMENTS EXTERNAL TO THE SCHOOL (UNITED NATIONS, SKETCHING SCENES, ECONOMIC SYSTEM, MUSICAL ACCOMPANIMENTS), AND CONVERSATION. (MD)

ERRATA

This copy of the final report contains some typographical errors which will be corrected in a later edition.

If you wish to keep a copy of the report permanently, please return this volume in exchange for a corrected copy.

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USE OF TECHNICAL MEDIA FOR SIMULATING ENVIRONMENTS TO PROVIDE INDIVIDUALIZED INSTRUCTION

Cooperative Research Project 1948

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First Supervisory District
Westchester County, New York
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Bedford Hills, New York

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PREFACE

Approximately three and one-half years ago the District Superintendent of Schools in Northern Westchester County, New York, suggested to officials of the International Business Machines Corporation that informal talks be scheduled periodically concerning educational research. He indicated that IBM had the technical talent and hardware for research and that the schools had the educational experience and the raw materials--a dozen autonomous school districts with (now) approximately 34,000 pupils and 2,000 teachers.

This initial suggestion from the public schools was explored by IBM, and many discussions involving educational philosophy, research, and practice indicated that a continuing informal relationship would be of considerable help to the schools and perhaps, also, to IBM. Since the first discussions the schools were alerted to identify one of their interests which was also shared by IBM, so that a more formal relationship might produce a sizeable joint undertaking. From the general common interest of automation in education, the specific concern for simulated modes of instruction evolved. Acting on this suggestion the District Superintendent of Schools, an area representative of the New York State Education Department and chief executive officer of the Board of Cooperative Educational Services (BOCES), the chief school administrators of the local school districts, and the BOCES research coordinator met with Mr. Bruse Moncreiff and Mr. James Dinneen of IBM to discuss research possibilities in the areas of retrievability and simulation.

In a summer workshop during July and August of 1962 BOCES and the Advanced Systems Development Division of IBM jointly sponsored a summer workshop to explore the possibilities of the simulated environment mode as a method of instruction. Ten teachers from the public schools of Northern Westchester began the study of eight learning units for which individual tutoring could be provided through the aid of audiovisual equipment controlled by a computer. Following this Dr. Wing, the BOCES Research Coordinator, drafted a proposal which was submitted to the Cooperative Research Branch of the U. S. Office of Education and resulted in the granting of funds for Cooperative Research Project 1948, the subject of the present report.

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PART I

RATIONALE

Statement of Purposes

The general purpose of the research in this project has been to obtain an estimate of the effectiveness with which the simulated environment mode could be used to teach certain units in eight different subject areas.

Definition of "Simulated Environment Mode"

The simulated environment technique is a method of instruction designed to provide individual students with a substitute for the pertinent features of a natural or conventional learning situation and to perform the tutorial functions of a teacher when needed within that setting. This simulation structure is realized through the appropriate selection, organization, and manipulation of instructional materials and the use (ultimately) of audiovideo display and response devices backed up with technical resources, such as a computer, for the storage, retrieval, and processing of information.

Assumptions about Instructional Method

This simulation project is based upon a concept of instruction which should be made explicit in order to give coherence and meaning to the empirical tests described in the report. In the absence of a generally accepted theory explaining and justifying methods of instruction, a brief ad hoc theory is here advanced.

The rationale for the use of simulated environment modes is couched here in terms of individualization of instruction. The terms "individualization", "meeting individual needs", and " providing for individual differences" are often used in an unanalyzed way to reflect the idea that each learner differs from every other and so must be taught in a unique manner in order to learn in the most effective way. Individualization represents a concept which is part of a theory of instruction that we are not prepared to expound in depth and detail. We assume, however, that an adequate theory of instruction would be based on a reasonable philosophy of education, and on an analysis of learning theory to the extent that present theories of learning are useful.

The philosophy of education provides a reasoned synthesis of educational goals and objectives based on analysis of broader human values. For our purposes the philosophy of John Dewey would be satisfactory. The learning theory, perhaps in an eclectic synthesis of current psychological hypotheses, should supply explanations of how learning takes place.

A theory of instruction might provide a rationale for the arrangement of conditions in a planned learning environment. These conditions would be based on principles drawn from learning theory guided also by a set of objectives consistent with a chosen philosophy.

When an instructional theory is expressed in terms of individualization, a logistic orientation is introduced, that is to say that attention is focused on the problem of supplying adequate instruction to single units of the student body. Although attention is directed to the "distribution" of educational opportunity, there is also the likelihood that when careful examination has been made of each individual's needs it will be found that the traditional repertory of school subjects is inadequate.

Students obviously differ from each other in their state of knowledge or skill, their need to know or learn some skill, their aptitude for learning, and their interest in learning. In some cases these differences may be so extensive that it is clearly pointless to give the same kind of instruction to two pupils at the same time. In another situation, as in the introduction of a new kind of learning, it may be that these differences are insignificant. The problem here is clearly one of diagnosis.

The learner is part of a learning environment which consists of some setting or environment, objects which are perceived by the learner through the medium of his senses, sometimes other learners, and usually a person trying to teach him something. Much learning in the life of a school child takes place outside of school in an unstructured fashion and without the conscious effort of someone to train him. In the school the teacher attempts to control the learning by employing a number of techniques, such as lecture, demonstration, question and answer, assignment and home study, discussion, laboratory work, and field trips.

These learning situations differ in respect to

1. Content of learning (main topic, subject).
2. Scope of content, that is, the range of material to be learned.
3. Pace of learning, the rate at which students learn.
4. Sequence or structure, or the order in which topics are presented.
5. Difficulty, depth of the subject matter or learning experience.
6. Mode of sensory presentation or representation, for example, the printed page, films, chalkboard drawings, tape recordings.
7. Control, i.e. by teacher or student or environment.
8. Style, mode; examples might be an inquiry method, explication de texte, a Socratic dialogue.

9. Response capability, by which is meant the ability of the teacher or other active elements of the learning situation to react appropriately to what the student says or writes.

In order to provide for individual differences among learners, the learning situation should be adaptable enough to allow appropriate variation in these ways:

1. Change of content
2. Extension of scope
3. Change of pace
4. Alteration of sequence
5. Variation of difficulty
6. Switching of presentation modes
7. Transfer of control
8. Change in style
9. Versatility in modifying response techinques.

Learning environments can be differentiated as to their potential for individualizing instruction by their capabilities for providing flexibility in the nine categories above. The individualization would be effective only when there was a combination of learning circumstances which would be appropriate to the diagnosed characteristics of the individual learner.

Need for Improvement of Present Instructional Methods

In the traditional school the teacher usually works with a group of pupils varying in number from twenty to forty, brought together because of a common age in the elementary school and by the schedule in the high school. The teacher may lack detailed information about his pupils and in addition be faced with a very difficult problem of finding appropriate ways of teaching them as individuals. Some teachers, to be sure, are fairly successful in providing a suitably differentiated learning situation for the individuals in a class in spite of the difficulties of making one mind attend to a score or more other minds.

Historically many different ways have been tried out for improving the individualization of instruction by modifying the organization of classes within a school. Sometimes different curricula or tracks have been instituted, as for the honor student and the slow learner. Homogeneous grouping within a curriculum is a common practice as well as special classes. Recently Advanced Placement Classes have been organized in many schools.

Other procedures include unit plans, special projects in an independent study program, guidance programs with emphasis on individual advice, and enrichment programs. Add to these the use of teacher aides and lay readers.

Recently physical arrangements such as the learning laboratory, the carrel, the library, and the corner of the classroom have been used to allow for the operation of the new electronic media.

In spite of these tactics and the laudable efforts of perceptive teachers to run a thirty-ring circus in the classroom, on the whole we are still far from successful individualization, and so we should carefully examine the growing repertory of new methods and technological aids to see what contribution they can make to individualization.

Simulation

Definition.--One method which offers possibilities of providing greater individualization is simulation, a technique by which the essential features of some object or process are abstracted and recombined in a model which represents the functions of the original and can be manipulated for the purpose of study or instruction.

The simulated environment mode, previously described, is a special case of simulation in which the emphasis is on simulating the useful features of a learning situation.

Examples.--Some of the best known simulations historically have been engineering devices, such as wind tunnels for testing scale models, the Link trainer, and the present day simulated cockpit of the supersonic transport.

Another form of simulation is the war game defined as "the means for simulating the play of systematic strategy or tactical operation of opposing forces including two-sided maneuvers, chart maneuvers, electronic maneuvers, board games, tactical games, or strategic war games."[1]

Business and management games are used by universities and corporations to train executives. Examples of this are the economic games of Dill,[2] the IBM game,[3] and the Univac Game,[4] in which competitive business situations are simulated and the decisions made by the players are analyzed by a computer to demonstrate to participants the organization, planning, information transfer, analysis, review, interaction, and dynamic nature of business.

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[1] "Brief History of War Gaming," The United States War College, Part IV.

[2] William Dill, "A Complex Management Game as an Environment for Learning." Paper delivered at IBM conference on Simulated Learning Environments. Thomas J. Watson Research Center, Yorktown Heights, New York. June 28, 1962.

[3] General Information Manual. IBM Management Decision-Making Laboratory. Manual of Operation. (White Plains, New York. IBM Technical Publications Department, 1963).

[4] Marketing Management Simulation. Remington Rand Univac, 1963.

Other examples are simulation of medical symptoms for training in diagnosis[1], international relations games[2,3], and the exercises used to train radar operators in the SAGE system[3].

Some distinctions.--In a broad sense simulation is a kind of imitation. Imitation generally consists of copying or mimicking something whose original history, flavor, inspiration or quality can only be superficially duplicated. In this class we have impersonators on the stage, parrots and Minah birds, and simulated pearls. Related to this connotation is the use of "simulation" to stand for an act whose intent is to deceive, as in the case of camouflage or the pretense of real emotion. When simulation is restricted for our purposes, it does not have the meaning of deception or mimickry. The emphasis is on the abstraction of essential functions for purposes of analysis or education.

Games.--One variety of simulation is gaming. Some writers attempt to make clear distinctions between gaming, simulation, and other related operations; others treat simulation and gaming as roughly synonymous.[1] Some games, at least, have the special character of competition between players, or the player competes against the model. In the end someone wins. There is often, too, emphasis on the player assuming a role of some sort. These three features make the game important as a motivating device for students.

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[1] John A. Swets, "Some Possible Uses of a Small Computer as a Teaching Machine." Datamation (June 1964.)

[2] Harold Guetzkow (ed.). Simulation in Social Science: Readings, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962.)

[3] Harold Guetzkow, Chadwick F. Alger, Richard A. Brody, Robert C. Noel and Richard C. Snyder, Simulation in International Relations, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1963.)

Advantages.--Simulation enables tests to be made under controlled conditions which would be difficult or impossible in real life. The biology project in this report, for example, enables students to simulate the collection of a raw sewage, a procedure which if actually carried out would be too dangerous for the public school laboratory. It also allows the student to pretend that he is using expensive equipment, such as an autoclave, which a school could not normally afford.

Simulation also permits the compression of time. For example, by the use of time lapse photography a twenty-four hour incubation of bacteria can be shown in a few minutes.

Simulation in education.--If we first list the kinds of things which can be simulated, we can see the hypothetical utility of simulation for education.

The environment in which a student learns contains many features which can be represented by pictures and recorded sound. Laboratory equipment is an example. In the chemistry project the products of mixing certain substances can be photographed and shown as slide projections. An outdoor view can be photographed and displayed.

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[1] An informative analysis of the vocabulary of simulation is contained in Richard E. Dawson's Chapter "Simulation in the Social Sciences" in Harold Guetzkow, Simulation in Social Science: Readings, op. cit.

Several activities of a teacher can be recorded and presented by audiovisual devices. The lecture, for example, or the demonstration can be recorded by a movie or television camera and projected when needed.

When data processing equipment, such as computers and their terminals, is available, even the conversational interaction between a teacher and pupil can be simulated to a degree.

Equipment

Non-computer-based.--Project 1948 was a pilot experiment designed to discover what kinds of simulations were suitable for computer control. The equipment used was of an intermediate, sometimes semi-automated sort usually operated by a teacher. Equipment included:

Carousel slide projectors (Kodak).

Wollensak tape recorders.

The audio section of a Perceptoscope.

(For some uses the Carousel projectors were synchronized with the Perceptoscope tape recorder.)

An Ampex 300 series stereo tape recorder, consisting of a 1/2" four-track transport and a 1/4" two-track transport

Movie Projectors.

Also for production purposes:

Kodak Reflex 16 mm camera with synchronous 24 frame per second motor and special single frame stop motion drive.

Portman Animation stand.

Zeiss Contarex 35 mm still camera.

Computer-based.--The electronic equipment now available has greatly increased the potential of simulation with its ability to store enormous amounts of data, make rapid calculations, print out results at great speed and perform feats of logic. Towards the end of Project 1948 the Sumerian Game was programed to operate from a 7090 computer, time shared, for which the output device was an IBM 1050 typewriter terminal controlled by the central processing unit.

Related Research

Normally we would hope to locate in the literature and report here some findings which would give direction to the hypotheses in the current project. Some direction has indeed been provided by all of the research and speculation on individual differences. But it would be a project in itself merely to list all of the background materials in psychology and education which bear on the simulated environment mode or on individualization.

Since Project 1948 has been an exploratory effort in a search for new ideas on how to simulate learning situations, the most relevant kind of related research has been the parallel explorations of simulation possibilities being carried on in universities and corporations elsewhere in the country. It was our opinion that readers of this report would be most interested to find a summary of research activities under way at other places where computer-based simulations are being studied.

PLATO

Since 1960 the Coordinated Science Laboratory (CSL) at the University of Illinois has been developing an automatic teaching system called PLATO (Programmed Logic for Automatic Teaching Operation) exploring possibilities of automation in individual instruction.[1]

There have been three models of PLATO. The first consisted of a single student station connected to ILLIAC, a medium-speed computer. The second model had two student stations and was used to study the problems created by multiple student use of the system. The third model has twenty student stations connected to a CDC 1604 computer.

At Illinois the personnel of the CSL have experimented with two basically different types of teaching logics, a "tutorial logic" and an "inquiry logic". In a lesson that uses the tutorial teaching logic, the system first presents facts and examples. and then asks questions covering the material presented. The student composes answers and asks the system for a judgment. If he finds the questions too difficult, he may branch to easier material. There is also a retrieval logic permitting the student to request information.

The inquiry teaching logic, on the other hand, can be characterized as a system permitting dialogues between the student and the computer. One version permits the student to solve mathematical problems that require many lines of work and in which all possible solutions cannot be anticipated. The student is informed whenever he violates a rule of mathematical logic, as if he had a teacher who told him when he had made an error but not what he should have written.

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[1] This description is taken from Bitzer, Donald L. and Easley, J.A. Jr., "PLATO: A Computer-controlled Teaching System." Paper presented at the annual convention of the Department of Audiovisual Instruction in Rochester, New York, April 22, 1964.

Another teaching logic has been designed by Richard Suchman to teach sixth graders elements of scientific inquiry. At the beginning of a unit the pupils are shown a film in which a physical phenomenon is displayed. Each student is then asked by a set of questions to explain this phenomenon. To get information he can check the properties of the objects pictured by progression through a series of questions branching logically from larger to smaller classes of properties.

Two conclusions drawn by the experimenters at Illinois from studies of the teaching logics with small numbers of students are:

1. The students appear to learn as well via the PLATO system but need less time than in a regular class.

2. With calculations based on 50,000 student requests obtained with the lesson material, a queueing study was performed. It was determined that a general purpose computer. having a high speed memory capacity of 1,500,000 bits would allow 1,000 students to be tutored concurrently on eight different lessons.

As a developmental project PLATO has produced results of considerable significance and interest to other investigators.

IBM'S INSTRUCTIONAL SYSTEMS DEVELOPMENT DEPARTMENT

Since 1958 the study of computer-assisted instruction has been going on at IBM's Research Division. The main pieces of equipment have IBM 1050 typewriter terminals and most recently experimental random access slide projectors and tape recorders, a central processing unit consisting of 1400 series computers, a multiplexing unit which controls traffic of data between terminal and computer, and disk drives where the instructional material is in storage and available in any order.

A student seated at the typewriter terminal reads instructions and questions automatically typed out for him by the terminal according to a prestored program and then types back the answers. These answers are analyzed and corrected by the computer and a response or the next question is typed out in turn.

The programs have contained a kind of multiple response item and proceed in an ordered sequence with branching possibilities.

Subjects programed to date have included statistics, stenotypy, German, computer languages, and more recently some elementary and secondary school subjects.

A new and promising program invention has been IBM's Coursewriter, a system consisting of a set of two-letter instructions which enable a teacher without a background in computer technology to store in the computer a sequence of questions or instructions and responses to right and anticipated or unanticipated wrong answers.

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[1] References: "IBM Progress Report: Researchers Use Computer System for Instruction." Teaching Aids News Vol. IV, No. 20 (October 1964). Also Press Release, IBM Data Processing Division, October 1964.

Another promising programing development is called "partial answer processing," by which the student is informed of what parts of a word he has misspelled or omitted. This process has many variations under exploration.

In this system the typewriter terminals can be remoted from the central control unit by telephone line through Bell Telephone 103 Dataphones. Taking advantage of this capability, faculty members at the College of Education of The Pennsylvania State University are preparing four courses for use by students at a typewriter station connected by leased telephone lines to a computer in IBM's Instructional Systems Development Department at Yorktown Heights, New York. The courses being written at Penn State are regular university credit courses in cost accounting, engineering economics for advanced business and engineering students, mathematics for education students, and audiology for majors in special education.[1]

With the cooperation of IBM and The Florida State Department of Education an experimental program is going on at Florida State University utilizing typewriter terminals also remoted from IBM's I.S.D.Department in Yorktown Heights. Subject matter now being developed includes solution of trigonometric identities, educational measurement, non-metric geometry, learning paired associates, test validity, and stress and strain tensions. The program is reported to work as follows:

The lesson takes the form of text which the student studies, either for as long as he wishes or for a predetermined time. The typewriter terminal next prints out questions under computer control.

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[1] Under a grant from N.D.E.A., Title VII B, in a project directed by Harold E. Mitzel and Kenneth H. Wodtke.

If a student responds correctly on the keyboard of the terminal, the computer will - in a typical course - then present another portion of the lesson for study. For incorrect answers, however, the course author will have previously entered other information into the computer which is presented to the less proficient student. This can take the form of additional remedial reading plus alternative questions which guide the student at a slower pace toward an understanding of the material.

SMALLWOOD'S DECISION PROCESS

Richard Smallwood, formerly at M.I.T. and now on the staff of the Stanford Electronics Laboratories, has made a study of a decision process designed to use the instructional history of a student to decide which presentation of the material is best for him.[1]

In Smallwood's system a large network of information blocks is assumed to exist for each concept to be taught. As the student proceeds through the instructional program, a record is made of each question that he answers correctly or incorrectly. By means of a model in the computer program, an estimate is made of the probabilities that the student will answer the question which is part of each instructional block. Working from this model the computer calculates the succeeding blocks which a student should receive, adjusting calculations to student performance as the program proceeds.

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[1] Richard Smallwood, "A Decision Structure for Computer-based Teaching Machines," Computers and Automation, (February, 1962.) See also his book, A Decision Structure for Teaching Machines. (Cambridge, Massachusetts: The M.I.T. Press, 1962).

A demonstration of this technique was made at the M.I.T. Computation Center with twenty students using three interconnected pieces of equipment: (1) a microfilm reader; (2) an electric typewriter: and (3) an IBM 709 computer. As a student viewed a paragraph of information about geometry on the microfilm reader, he answered the terminal question on a pad. He then advanced the microfilm reader forward one frame to where a list of possible answers to the questions was displayed and typed the number corresponding to what he considered the best answer.

While the computer was advancing the microfilm to a frame which explained to the student whether or not he had selected the right answer, the computer calculated the next block that the student should receive. This process was continued until each student reached a final set of test questions.

At the end of the instruction the student's responses were used to update the parameters needed by the system's decision process.

It was demonstrated that the teaching system could make qualitative decisions in its presentation of the course material to students so that different ones, depending on their past performance, received different presentations. The computer also changed the decision process with experience.

S.D.C.

Since 1959 System Development Corporation (S.D.C.) has been experimenting with automated instruction. In early 1960 a Bendix G-15 computer was installed as the control unit for a student station which included a random access slide projector and an electric typewriter. Each slide contained one instructional item. The student responded to multiple choice questions contained in the items by pressing appropriate keys on the typewriter. The computer could project the slides in any sequence.[1]

In 1961 the CLASS (Computer-based Laboratory for Automated School Systems) system was set up at S.D.C. A Philco S-2000 computer is the central control mechanism for a general purpose educational laboratory in which twenty students may be instructed simultaneously. CLASS operates in much the same way as the Bendix system described above but with some simplification. Each student has a manually operated film viewer containing 2,000 frames of instructional material and in addition a response device linked to the computer which indicates the sequence of slides to be seen, which enables the student to respond to the questions, and which presents knowledge of results to the student in the form of coded lights.[2] (One program taught at CLASS this way has been French.)

The computer also maintains performance records on each student.

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[1] John E. Coulson, "A Computer-based Laboratory for Research and Development in Education," Programmed Learning and Computer-based Instruction (New York: John Wiley and Sons, 1962.)

[2] Donald D. Bushnell, "The Role of the Computer in Future Instructional Systems," AV Communications Review, XI, No. 2 (March-April 1963).

SUPPES PROJECT AT STANFORD

Under the direction of Patrick Suppes at Stanford a computer-based laboratory has been constructed in which elementary pupils are studying programs in mathematics.[1]

The laboratory consists of six student stations each comprising an IBM terminal which displays a microfilm image on which the student may respond with a light pen and a Philco cathode-ray tube with accompanying typewriter keyboard. Also to be delivered was a Westinghouse audio system providing random access to prerecorded messages.

In this laboratory twelve first graders have been studying a complete mathematics curriculum,and two bright second graders have been taught mathematical logic.

The microfilm projector can display any one of the 512 individual pages of text on a screen which can be divided by a shutter into eight separately controlled sections. The student responds to the display either by means of a light pen or the typewriter. When the light pen is touched on a part of the display screen, the coordinates of the point are transmitted to the computer.

According to the report, the IBM device is particularly valuable for showing complicated visual displays requiring art work or complicated line drawings. The cathode-ray tube is especially good for showing problems that require complicated answers to be inserted in the context of the display itself.

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[1] Stanford University News Service press release, Stanford, California, March 30, 1965.

As a result of experimentation with the laboratory thus far, these conclusions have been drawn:

1. There is extensive accommodation to individual differences, each child working at his own pace.
2. The computer can evaluate and record each answer given to each problem by every student for purposes of data recording and analysis.
3. By such analysis an entire course can be studied to determine difficulties the students may have with each concept.
4. Teachers may turn routine tasks over to the computer and be available for work with individuals.

MICHIGAN STATE UNIVERSITY

Charles Frye of Michigan is conducting a computer-based experiment this year using the IBM AN-FSQ-32 system at S.D.C. The plan calls for students to operate the computer on a real-time basis using it both as a teaching machine and a calculator. The computer is programed at the request of the student to present statistical problems, manufacture populations, present data which have been sampled from the populations, assist in the computation, evaluate student performance, and give remedial help. By this method Frye hopes to train persons who will be expert in both statistics and computer procedures.

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[1] Charles Frye. "Simulated Statistical Inference: Computer Utilization for Instruction." A Cooperative Project Between Michigan State University and System Development Corporation. Papers of the Learning Systems Institute #8. College of Education, Michigan State University, 1964.

THE EDISON RESPONSIVE ENVIRONMENT INSTRUMENT[1]

Several years ago Professor O. K. Moore began conducting research into the possibility of using a controlled typewriter to teach reading to very young children. This research led to the development of the Edison Responsive Environment Instrument (E.R.E.), which is a computerized typewriter with capabilities of reproducing several of the response actions of a human teacher. This system was used during the 1963-4 school year at the Atkinson School in Freeport, Long Island, to teach kindergarten pupils to read and is now in use at several other locations.

When a pupil depresses a key on the typewriter keyboard, the key-symbol is typed in large type-style on the typewriter paper and is pronounced at the same time. Once a key has been depressed, no other key can be depressed until the audio-pronunciation is complete. There is also a rear-projection screen on which letters, words, sentences and stories can be automatically displayed with accompanying audio explanations. A pointing mechanism can point to letters, either in isolation or gradually coupled with other letters to form words, in order to expand gradually the visual focus of the pupil.

Any symbol pointed to by the E.R.E. is also "encoded" in the keyboard, that is to say that this particular key is the only one which can be operated by the pupil and will type its symbol on the typing paper while all other keys are blocked and will not function.

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[1] John Henry Martin, "Freeport Public Schools Experiment on Early Reading Using the Edison Responsive Environment Instrument." (New York: Responsive Environments Corporation, 1964.)

According to Dr. Martin, a typical operation would be for E.R.E. to point out a particular letter, to pronounce this letter to the pupil, and to free the one, single, particular key corresponding to this symbol for manual operation by the pupil. The moment the pupil depresses this key, the pointer will move to the next symbol, pronounce it, and free the corresponding key on the keyboard. As the pupil proceeds from letters to words, an additional audio system takes over which can pronounce words, sentences, or stories in a recapitulation signaled by depressing the space-bar and by other signals.

The system can also record the pupil's voice and play it back to him so that he can compare his oral versions with prerecorded models.

Twenty kindergarten children five years old, with intelligence quotients ranging from the 140's to the 50's, were taught by means of the E.R.E. equipment and their progress compared with that of a control group taught by two competent teachers using enriched traditional reading methods. Equivalency of the two groups in intelligence and reading ability was established by careful statistical analysis.

After five months of instruction the twenty kindergarten and mentally retarded young children in the experimental group were reading significantly better than those in the control group with a mean difference of 1.7 months in favor of the experimental group.

Thus the E.R.E. simulates these functions of a teacher: it talks, listens, accepts and presents information, and comments or explains in a wide variety of structures. The learner, in his turn, can build words from their visual and audible components, type them, speak to them, and compare his pronunciation with a model.

CIRCUIT JOB SHOP SIMULATION AT JOHNS HOPKINS[1]

Professor William A. Huggins at The Johns Hopkins University has used a combination of a 7090 and a 1401 computer to teach a unit in electronic circuit design.

The simulation is designed to simplify the problem of obtaining real circuit components. When an engineer designs a circuit, he sends the circuit diagram to an electronic job shop together with a job order for, say, ten units, and then receives from the job shop cost data and test results. On the basis of this information he may decide that the circuit is ready for production or he may decide to change the design and try again.

The actual maintenance of a real job shop of the required capacity (especially when the designers are in fact students) would be expensive and time consuming. By simulating the job shop on a digital computer it is theoretically possible to save cost and time. The simulation is intended to be realistic in the sense that communication between designer and machine closely approximates (at least in substance) communication between designer and shop.

The simulation is capable of handling static, direct-current circuits made up of resistors, voltage sources, and current sources, and of providing input and output (G) parameters for the circuit (optional).

The circuit is specified by a parts connection list (Heathkit style) rather than directly by a circuit diagram. This list includes one line for each component, giving the physical characteristics of the component and the terminals to which it is connected. A final line specifying the location of ground and the number of units to be constructed is also written.

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[1] Nancy R. Lakey, "Circuit Job Shop Simulation." (mimeographed) (undated).

Any tests to be performed are also specified on the appropriate lines.

Specification of inputs.--The student makes up a specification list which is delivered to a 7090 computer via a 1401. Four different types of lines may occur in the specification:

Resistor - type 1
Voltage Source - type 2
Current Source - type 3
Last Card - type 4

Types 1, 2, and 3 may each contain the following items:

1) type number
2) component number
3) initial junction number
4) terminal junction number
5) nominal value
6) power rating
7) tolerance
8) resistance test
9) voltage test
10) current test
11) power test
12) cost

The simulator then provides the following output: 1) statement if the circuit is infeasible, 2) cost per unit, including any tests required, 3) identification of any burned out components for each unit, 4) listing of requested test results for each unit, 5) input, output parameters for the circuit (optional).

In this manner the job shop has been simulated at a saving of time, manpower, and material by use of computers as an auxiliary to instruction.

GAMES AT JOHNS HOPKINS[1]

Several different kinds of games have been developed at The Johns Hopkins University under the leadership of James Coleman.

The first year of research was devoted to an election game, which combined actual data on a sample of the electroate with a program responsive to the decisions of candidate teams, played by high school students. A set of decisions made during one class period was analyzed by a computer and the consequences of team decisions were made apparent to the students the following day. The delay in obtaining feedback slowed down the game to the point where a different strategy was tried.

The staff under Professor Coleman simplified the social and economic environments in the games so that they could be played without the computer. Under this arrangement the following games were invented:

a) A career game designed to give students experience in making complicated decisions about education, jobs, and family life.

b) Three democracy games - legislative, designed to show the dependence of a legislator's reelection upon his ability to satisfy the desires of his constituents; direct, and representative, which combine features where students are citizens voting.

c) A family game.

d) A school board game

This year several games have been invented which are delivered via typewriter terminals controlled by an IBM 1401 computer. These games have included arithmetic and reading games and appear to have generated high interest on the part of subjects.

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[1] James S. Coleman, *et al.* *Research Program in the Effects of Games with Simulated Environments in Secondary Education*. Report No. 1 (October, 1963), The Johns Hopkins University (mimeographed).

BOLT, BERANEK AND NEWMAN[1]

For several years experimentation has been going on at Bolt, Beranek and Newman, Inc., in Cambridge, Massachusetts, under the leadership of Wallace Feurzeig and John Swets.

In 1963 the first version of their Socratic System was programed for the PDP-1 computer with an on-line typewriter and auxiliary drum memory. In the Socratic System the student is presented with a problem and a vocabulary list to which he is limited. In a dialogue with the computer the student types questions or assertions and the computer responds appropriately, conditioning its responses on the previous entries by the student.

More recently a program in medical diagnosis has been written by Swets and Feurzeig in collaboration with Preston Munter and Myra Breen. In a typical case the computer system describes the symptoms of a patient and engages in a dialogue with the student as he attempts to diagnose the illness. The student may ask for information, guess at a diagnosis, or answer questions while the system reacts by correcting, concurring, supplying information, and generally guiding the student to a correct diagnosis.

The program has promise as an application in the field of medical training and demonstrates ingenuity in the use of conversational interaction between student and progmm.

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[1] Wallace Feurzeig, "Conversational Teaching Machine," Datamation (June, 1964).

Related Research-Comments.--In addition to the research summarized in this section there is other experimentation of importance being carried on, such as Stolurow's study of basic programing techniques at Illinois, Herbert Fraser's games at Washington University, Bert Kersch's simulation of classroom behaviors for training teachers, and a different approach to the same problem by Ted Ward and Donald Freeman, at Michigan State. Other significant research is unreported here because it does not fall within the class of computer-aided simulation or because we have not found out about it.

The approach to simulation in the studies summarized above is to make use of a typewriter console, sometimes with added equipment for presenting sound and visual stimuli, and to concentrate on teaching those topics which a computer can handle with some ease.

These techniques result in providing variability in pace for each student and give promise of a methodology which could make instruction adaptive to the individual character of the learner.

Several different teaching logics have been applied or created.

1. Linear Program. In some cases the computer-aided equipment is used to present sequences which do not differ substantially from the programed materials otherwise available in book form. This material consists of a series of items which characteristically provide a bit of information and then an opportunity for a student to make a simple constructed response to an item which queries him and aids him with varying amounts of cueing. The student then learns immediately whether he was right or wrong.

2. Multiple branch program. The so-called "intrinsic" style of program usually gives the student several alternative answers. If he chooses one of the wrong answers he is given a clue, an explanation, a repeat, or a reprimand.

3. The "tutorial" logic. The essentials of a tutorial session are that there is one tutor, or expert, present, and one student, or few enough students so that each can participate in a discussion.

In actual experience the tutorial dialogue can take many forms. The tutor may lecture. He may ask the tutee for a report. There may be a democratic exchange of ideas, or a quiz-like exchange in which the tutor passes judgment on the answers of the student.

When we talk about a "tutorial logic" in programing we have in mind this correctional or responsive function of the tutor. The tutor should be able to react to the ideas which the student expresses and correct them, or praise them or contradict them, or edit them, or suggest some source from which the student may get additional relevant ideas.

It is of course difficult to program a computer so it can analyze a constructed response of any complexity and react to it in a helpful way. But one method of handling this problem is to direct the students' answers into a prearranged form, e.g., by setting up true-false or multiple choice answers with an appropriate rejoinder in storage for each correct or incorrect answer.

Another technique is to restrict the answer to one word or phrase which the computer can recognize and respond to differentially. Programers are becoming more adept at analyzing constructed responses even to the point of accepting misspelled words and indicating the wrong letters to the student.

4. The Inquiry Logic. The inquiry process has been the subject of much discussion since (and before) Dewey's analysis of scientific thinking. But merely by discussing inquiry we infringe upon the freedom from restraints which the creative inquirer needs for his purposes. The inquirer, in attempting to find a solution to some problem, may follow paths of nearly infinite variety. He may commonly go through steps of analyzing the problem, collecting data, forming hypotheses, interpreting data, and testing his solution, but he will not necessarily proceed in a fixed sequence.

This indeterminate nature of inquiry makes it difficult even for a computer to control, apart from the difficulty of analyzing complex constructed responses. Suchman's method calls for a presentation of a problem by film and then a series of decisions by which the pupil is guided towards a solution.

5. Games. The game structure, as described earlier, is based on a model representing a multi-factored situation in which variation of one factor will have an effect upon several or all of the other elements. In the game a student plays a part, competes with other gamesters or the computer, often wins or loses some kind of hypothetical prize.

6. Automated lecture. Expository descriptive text, visual or auditory, can be presented by means of equipment controlled by a computer.

A prevalent hindrance to effective adaptation of instructional procedures to individual needs is the lack of systems which can effect and analyze student background, ability, and progress.

With the exception of efforts at systematic analysis of school logistics being done at SDC, there is little attention to the problem of educational counseling and test interpretation which must eventually be closely articulated with purely instructional applications of data processing. For this reason the decision method used by Smallwood is important.

These experiments have encouraged us, at various stages, to explore different logics, to attempt to simulate other elements of learning environments, to apply these simulation methods to a variety of school subjects, and to begin to incorporate evaluative techniques into the instructional programs.

Objectives

In the original proposal the objectives of the project were stated in this form:

"II. Objectives. The aim of this investigation is to find answers to such questions as the following:

1. How effective are simulated environment modes in helping pupils of certain age levels learn specified materials in areas such as chemistry, biology, physics, French, social studies, music, and art?

2. What rationale for the use of simulated learning environments is suggested by an analysis of the individual projects; especially in respect to these further questions: a) Is there a real danger of "dehumanizing" instruction through the use of machines? b) Can simulation modes be usefully classified according to the structure of the subject matter, the behavior elicited, the nature of the environment, the purpose of the simulation, or in other ways? c) Are such classifications useful in predicting what kinds of simulation will be effective for particular kinds of learning? d) What curricular modifications are possible or desirable

because of simulation? e) What scheduling problems arise through the use of simulation and what are the theoretical solutions?

3. What further applications in other subject fields and at other age levels are indicated?

4. How can the effectiveness of the procedures used in the employment of the simulated environment mode be accurately measured by later experimentation?"

The purpose of the experimentation was not primarily to test the usefulness of computer-based instruction but to study the simulated environment mode, for which the computer appeared to be one promising adjunct.

Hypotheses

No hypotheses were specified in the original proposal, but there were certain expectations in the minds of the project staff which could have been spelled out.

It was anticipated that some new simulation modes would be invented in the application of the simulated learning environment style to the different subjects to be taught.

It was also expected that some of these new modes would be practical from the standpoint of the technology then available and to be available within two years of the beginning of the project.

We thought that the students used as subjects for the experimentation would learn what was presented for learning in each of the subprojects. We expected that the kinds of learning presented would be appropriate for the age levels of the subjects selected.

As far as a rationale is concerned, it was hoped that some kind of answer could be found to the "dehumanization" accusation. We also had some conviction that a sort of prescription could be devised which would suggest what kinds of subjects were suitable for simulation and that other criteria for use of the mode would be discovered.

It was an hypothesis that the technique of simulating environments would suggest changes which could or should be made in the curriculum.

Finally we hoped to get useful ideas for designing subsequent projects which would provide more precise data.

PART II

THE SUBPROJECTS

ART[1]

The experimental unit in art was designed to teach esthetic principles of line as part of a basic course for students in grades nine through twelve. They were presumed to have had art classes once a week in elementary and junior high school but no previous formal courses.

The unit on line would follow a series of lessons dealing with the characteristics of different art media and would be followed by units on form, color, and texture as parts of a course which combined theoretical analysis with practice in the performance of drawing and painting.

The procedural objectives of the unit on line were twofold. The first was to give the student time, incentive, and a variety of media so that he could practice sketching as an exercise which all artists and art students must continually carry on to improve technique, sharpen observation, and develop personal style. The second was to present ideas about line variety, character, and manipulation as used in interpretive sketching. The student was encouraged to develop skill and style while gaining sensitivity to line as an element of communication and expression. It was hoped by these methods that students would acquire a background adequate to help them in forming personal tastes and making intelligent judgments in the arts. It was also an aim to seek out and develop the capabilities of the talented in art who might consider some form of art as a career.

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[1] The art project was under the direction of Frank Cassetto, art teacher at Yorktown High School, Yorktown Heights, New York.

Hypothesis.--The simulated environment mode used in the developed unit was expected to overcome the physical restrictions of the classroom and the immediate high school campus. The student was to have world-wide scenes to view and sketch from, thus escaping classroom confinement. It was hypothesized that the student would be at ease while sketching and uninhibited by classroom interferences, so that in a matter of three to five hours it would be possible for him to produce a number of sketches that might take ten to fifteen hours in a classroom situation.

The experimental environment was also expected to permit self-pacing, allowing each student to work at a comfortable rate and finish before or after the other students without any feeling of pressure.

Objectives.--The instructional objectives of the unit on line were:

1. To give the student time, flexibility and incentive to practice sketching.

2. To present the idea of line variety, character and manipulation as used in interpretive sketching, the student being encouraged to develop skill and style while gaining sensitivity to line as an element of communication and expression.

3. To make the student aware of drawings and prints done by famous artists from all periods and able to understand their line qualities.

Equipment.--The technological devices and combinations used were the following:

1. Tape recorder with a programming device synchronizing projection of slides with sound.

2. Tape recorder with microphone to record verbal responses of students.

3. Speaker connected to first recorder.

4. Carrousel projector.

5. Headsets for monitoring.

6. A screen for viewing.

7. A push-button or switch panel with a remote position control unit.

The two tape recorders, a panel control unit, and headsets were placed in a remote position and wired into a demonstration room. The demonstration room contained a carrousel projector, a screen, a speaker, a microphone and a push-button or switch panel.

An operator following the printed script and, listening through headsets, manipulated the equipment from a remote position while a student or an observer was enclosed in a small room.

The above devices are simulations of the ultimate technological equipment conceived for this project. All these functions could ultimately be incorporated into one console where computer-controlled devices could produce sound at will, and visual images or a cathode ray tube could be substituted for still slide projection. A computer should be able to record student responses and feed back either additional information if necessary or reward the student by accelerating his progress.

Procedures.—The slide sequence is divided into three sections. In the *first* section the student is taken on a simulated sketching tour in which he is shown slides of many attractive scenes in rural and urban settings in this country, in Italy, France, and other regions. He is asked to select two scenes by stopping the slide projector on scenes that he chooses and make line drawings of them. To help him with this sketching some line drawings of scenes which have been projected are shown to him.

In the second section of tape and slide synchronization the student receives an illustrated lecture on the subject of line analysis. He is given several fundamental principles about kinds of line, their effect on the viewer, and general esthetic considerations. He listens to comments made by other students about their reactions to different kinds of lines. Then he takes another simulated tour and draws the same scenes he sketched in Section I. An excerpt from the second section follows:

Line Analysis

You have drawn a good variety of sketches during your trip.

Let's hope the trip was pleasant and that it gave you opportunity to learn much about line sketching.

Now that you have practiced with so many lines, we are going to see if we can arrive at some fundamental conclusions about lines.

You must have noticed that a line is the simplest and most direct means of creating a design.

People all over the world understand a line that you draw, even though they may speak and write a language different from your own.

Notice that a child uses lines naturally and simply when he combines a tree, a house and then sticks in details like a dog, a fence and so on to make a crude yet recognizable landscape.

Any shape you draw can be first surrounded by line.

Here's a stack of vases for instance. (slide)

And here's a female figure. (slide)

See how the sides of buildings join together at the corners to form lines. (slide)

We may call the sides of buildings planes. So wherever two planes intersect or meet, we have a line formed.

Let's see now if you can isolate the different characteristics of the lines which you used in your sketches.

Look carefully at this line composition. This is a group of lines organized in what might be called an abstract or non-objective arrangement. That is, the lines are not related to any specific subject or idea. They may represent for us so many different things. (slide)...

The third tray of slides contains a series of print comparisons. On a single slide there are reproductions of three prints by famous artists. At the bottom of the slide is a descriptive statement which applies more appropriately to one print than another. For example there may be three portraits of which one has soft, curving lines, and a statement to that effect appears on the slide. The student selects one print by writing 'a', 'b', or 'c' on a pad of paper. With this series of comparisons the unit ends.

Conclusions.--The art project was appraised by several methods.

Six art teachers from local schools and universities were asked to compare the sketches made before the instruction with those made by the same students after instruction. The general finding was that there was marked improvement in the latter set of sketches.

Students were interviewed by Mr. Cassetta after they had taken the lessons. He reported these reactions:

1. All students said they enjoyed the lessons.

2. All students stated that certain discoveries new to them were made concerning line.

3. All students felt that time passed quickly and underestimated the length of time spent on the project.

4. Students said they were particularly gratified at being able to work by themselves without pressure and deadlines.

5. All students except one said they did not mind the absence of a live teacher, but all indicated that at some point later on an art teacher would be needed to review their work for criticism and indications of progress.

By close observation of the students while they were taking the lessons the researcher came to these conclusions.

1. All students seemed to be completely absorbed in what they were doing. There was no evidence of distraction or mind wandering. One student was observed to be talking back to the tape recorder.

2. The time required for completion of the three phases ranged from one and a half to seven hours.

3. Students in the group going through the last revision of the unit made no requests for explanation from any source, outside of the prepared slides and tapes.

4. The amount and variety of work produced might have taken two to five times as long to accomplish in a classroom situation.

5. Students with limited facility for visualization and execution of ideas seemed to be greatly motivated and accelerated.

Implications.—The art project could be continued with profit into studies of color, form, and texture. It would also be interesting to introduce machine control so that some branching could be accomplished for purposes of repetition, alternate teaching, or correction.

It seems apparent that the simulation possible in a creative art course will have to be of a mixed mode, with a teacher available to judge the sketches made by the student.

It is also evident that by this automated technique carefully prepared instruction can be presented wherever tape and slide machines are available so that students can learn about art on an individual basis.

The comparison technique in the third section introduces the possibility of adapting the order of instruction to the skill which the pupil demonstrates in matching descriptions to pictures.

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II,B,1

BIOLOGY[1]

Aim.--The simulated microbiology laboratory sequence was designed to teach high school seniors about the role played by bacteriophage in DNA replication and cell transformation. In the process it was expected that students would learn some laboratory procedures.

Prerequisites.--The biology unit was written at a level of difficulty appropriate for students who had completed a year's study of general chemistry and biology and who had shown special interest and aptitude in science. It was also presumed that the students could make discoveries independently and possessed in addition to common sense a basic understanding of cell structure and physiology, mitosis, bacteriology and virology, and Mendelian genetics.

Objectives and hypotheses.--

a. Objectives.--

1. To prepare materials suitable for biology laboratory instruction.

2. To organize this material in the simulated environment mode for adaptive or remedial sequencing.

3. To measure the amount of learning which took place during the special lessons.

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[1] The biology project was under the direction of Kenneth Tice, biology teacher at Horace Greeley High School in Chappaqua, New York, and Dr. Stanley Kellerhouse, Director of Guidance and biology teacher at Croton High School, Croton-Harmon, New York.

4. To measure student attitudes towards instruction in the simulated environment mode.

5. To improve and expand the exposition of a rationale for simulation.

6. To make available an instructional unit program with visual components in the simulated environment mode capable of being programmed in a computer.

b. Hypotheses.—

1. That for science laboratory instruction, use of the simulated environment mode can result in at least as much learning as the use of traditional methods.

2. That the use of the simulated environment mode will result in favorable attitudes on the part of students toward the material taught.

3. That the simulated environment mode is a technologically practicable method of instruction for science-oriented students at the high school level.

Method.—The procedure followed in the administration of this instructional and testing program evolved from experience gained in testing a very limited number of students.

Since the mode was designed as individualized or tutorial instruction, the researcher set up individual appointments with student volunteers from the 11th and 12th grades at Horace Greeley High School, Chappaqua, New York. Both the instruction and the testing were done in a science classroom suitable for observation of slides and listening to tape recordings.

The first appointment involved the pretesting sequence. Approximately thirty minutes were required for administration of this test. No predetermined time limits were established. Approximately one week later, individual students scheduled appointments for instruction and final evaluation.

During the administration of the experimental instruction the student was seated at a conventional lab table with a clear view of the projection screen. The tape recorder and carousel were located behind him in the room.

The instructor was present at all times during the instruction and testing. His role was to synchronize the audio and visual output in response to the student feedback. His presence could be virtually eliminated, once the lesson units have been programmed for computer-based instruction.

Prior to the beginning of this fifteen lesson simulated laboratory, the student was oriented to the media with a short introductory explanation from the tape recorded script. From this point on he controlled his own rate of progress.

Early trials required the student to respond to the instructions and questions only by verbal responses. Subsequently a written response sheet was put in the hands of the student to enable him to compare his learning responses to those of the reinforcement output from the tape recorded script. Parenthetically, the response sheet served to aid the writer later on in making revisions in the instructional program.

Involving the student in the process of writing his responses tended to lengthen the instructional time lapse by as much as 30 percent. However, posttest results suggest that it can be a valuable aid in the process of learning.

Each student was given the opportunity to take short rest periods

(1 or 2) before completion of the entire fifteen lessons. The total instructional and posttesting required up to three hours; therefore the experimental subjects in no instance completed the entire simulated biology laboratory unit at one sitting.

The writer deliberately attempted to divorce himself from any active involvement in the instruction. However, when the student requested a repetition of the recorded instructions or projected photos his request was fulfilled by the "human computer" at the controls.

The fifteen lessons were entitled:

1. Collection of Raw Sewage
2. Pipeting Techniques
3. Effects of Raw Sewage on Bouillon
4. Sterile Laboratory Techniques
5. Preparation of Sterile Nutrient Broth
6. Inoculation and Culturing of Nutrient Broth
7. Preparation of Nutrient Agar Culture Plates
8. Inoculation of Nutrient Agar Plates
9. Isolation of E. Coli Bacilli
10. Growth Rates of Bacteria
11. Effects of Bacteriophage on E. Coli Broth
12. Developing Lawns of E. Coli Bacilli
13. Effect of Bacteriophage on E. Coli Lawns
14. Transformation Effect by Bacteriophage
15. Extraction of DNA from Bacteriophage

A sample of Lesson 9 is reproduced here:

LESSON 9

PROCEDURE FOR THE ISOLATION OF E. COLI BACILLI

Computer Information

In this procedure the isolation and culturing of E. Coli bacilli will be effected, using the E. Coli that were discovered in the sewage culture.

Computer Instruction

Observe a photomicrograph of E. Coli bacilli, 1000 X
Photo Display: A slide showing E. Coli magnified 1000X.

Computer Instruction

Observe a 24 hour streak plate made by streaking an inoculating loop of sewage culture on a sterile agar plate.
Photo Display: Streak plate of sewage on agar

Computer Question

Each spot represents:
1. Many types of bacteria.
2. No bacteria.
3. One type of bacteria.
4. Minerals in the agar.

Student Response

#3

Computer Question

The many similar appearing areas probably indicate (similar, dissimilar) bacterial types.

Student Response

Similar.

Computer Question

Examine a photomicrograph of a slide made from some of the material in one of these areas.
Photo Display: Slide of a photomicrograph of E. Coli bacilli (1000X).

Computer Instruction

In order to develop a pure culture of E. Coli bacilli, some of

The E. Coli from an identified colony on the sponge culture plate must be transferred to a sterile agar plate. A platinum wire loop will be used to effect this transfer.

Photo Display: 1. Streaking components loop, sponge
Two sterile plates and streak plates (not available yet).
Use Streaking components 3 plates and cold loop.
2. Flaming loop

Computer Question

Flaming the loop is necessary to insure that the loop is______.

Student Response

Sterile, uncontaminated

Computer Instruction

Touch the cooled flamed wire loop to the identified colony of E. Coli bacilli from the sponge plate culture. Inoculate several sterile agar plates by streaking the loop lightly over the agar.

Immediately after the administration of the simulated instruction the *fifty* question posttest was administered to evaluate the change in understandings. Test results were then immediately made known to each student. He was also given an opportunity to discuss and make comments at this time or give his overall reaction to this type of instruction.

An attitude scale[1] was then given to the student with a request that he record his reactions and mail it back immediately. This terminated the subject's, relationship with the project study.

Evaluation.--In January 1964 trial instruction and testing of three lessons from the total of fifteen were conducted with a group of thirty-nine students. The average gain from pretest to posttest for these three lessons was 13 percent. Major revisions in the instruction program were made between January and May as a result of these trials.

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[1] The attitude scale was constructed by Dr. Robert Campbell. It was originally intended to be an instrument for pretest-posttest comparison, but this use was abandoned.

Six students were individually instructed and tested on all fifteen lessons of the revised biology materials in May 1966. For these subjects posttest scores were 6, 20, 20, 26, 28, and 40 percent higher than pretest scores. The average of pretest scores was 63 percent; average of posttests was 80 percent. (The revised test is attached as APPENDIX A.)

Implications.--Our staff is convinced that the biology project should be continued, analyzed, and adapted for computer control. To this end two applications were submitted to the U. S. Office of Education for continuation of the project along with other projects. Both applications were rejected.

In our opinion further study should be made of simulation techniques for teaching laboratory procedures in biology as well as for providing an instructional environment in which the student may discover and learn theoretical principles in advanced biology. We see no reason why these techniques are not possible for computer control and hence for individualization of instruction.

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CHEMISTRY[1]

Purpose of the project.--The aim of this project was the simulation of the laboratory part of a course in inorganic qualitative analysis.

Objectives of the traditional course.--Traditionally, qualitative analysis has been a one-semester course given during the first semester of the sophomore year of college. In some colleges today it is concentrated into about one month's work and presented in the second semester of freshman chemistry. Occasionally it is found as a senior science course in high school for students with outstanding ability and interest in science. Prerequisite for the qualitative analysis course is either a year of general chemistry at the high school level or a semester at the college level.

Basically, a course in qualitative analysis is a study of the methods by which the elements in different mixtures of chemical substances can be separated and identified. There are two general purposes in presenting such a course. The primary aim is to teach the physical and chemical properties of the ions in their salt solutions - chemical equilibrium, the formation of complex ions, the relative solubilities of the different salts, and so forth. A second aim is to teach students good laboratory techniques, so that they can acquire skill in the manipulation of the ions and the handling of the equipment.

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[1] The chemistry project was developed by Andrew [illegible] of Briarcliff High School, New York, and John Hall of IBM. Dr. Stanley [illegible] of New Paltz State Teachers College, New York, conducted the tryouts.

Objectives of a qualitative analysis course taught by the simulated environment mode.—By separating the two aims to some extent, so that the time usually consumed in washing, heating, centrifuging, and mixing may be used to follow through the analytical scheme, the simulated procedures should permit the student to learn the facts and principles of chemistry more efficiently. It is expected that the student should be able to proceed through the complete analytical scheme by simulation several times, each time starting with a different mixture of substances, in the time normally taken for one analysis in the actual laboratory. In this way he would be able to become familiar with many more of the possible situations than is feasible in the laboratory time usually allotted. The experimental objective then, was to test the practicability of these simulation procedures.

Place of this simulation in the chemistry curriculum.—The student using the simulation equipment for qualitative analysis would already have taken a course in general chemistry and thus have gained some background and familiarity with laboratory equipment. Before sitting at the console of the simulator he would also have heard lectures or have read chapters giving basic information necessary for success in analysis. He would also have available certain textual materials including a chart of the analytical scheme being used. Before or after the simulation experience he might be given some days in a real laboratory so that in addition to the hypothesized superiority in comprehension of the principles of chemical analysis he would have a practical knowledge of laboratory procedures and techniques.

Simulation technology.—The chemical simulation is achieved by means of slides keyed to the student response. A vocabulary of about twenty-five procedures and fifty solutions of varying molarities constitutes the repertory of commands. Initially the student requests to the computer were oral and the machine's presentation was by projectors controlled by an operator who had knowledge of qualitative analysis and who was provided with a carefully arranged coded system for interpreting student responses and locating slides. Some 1500 color slides were prepared for this project, each representing a step in the analysis of the cations, in Groups I or II.

Since the original tryouts, the selection and control of stimuli has been programed for a computer, thus allowing for more flexibility in branching and recording of student responses. This programing has taken place at IBM's West Coast Laboratory of the Advanced Systems Development Division.

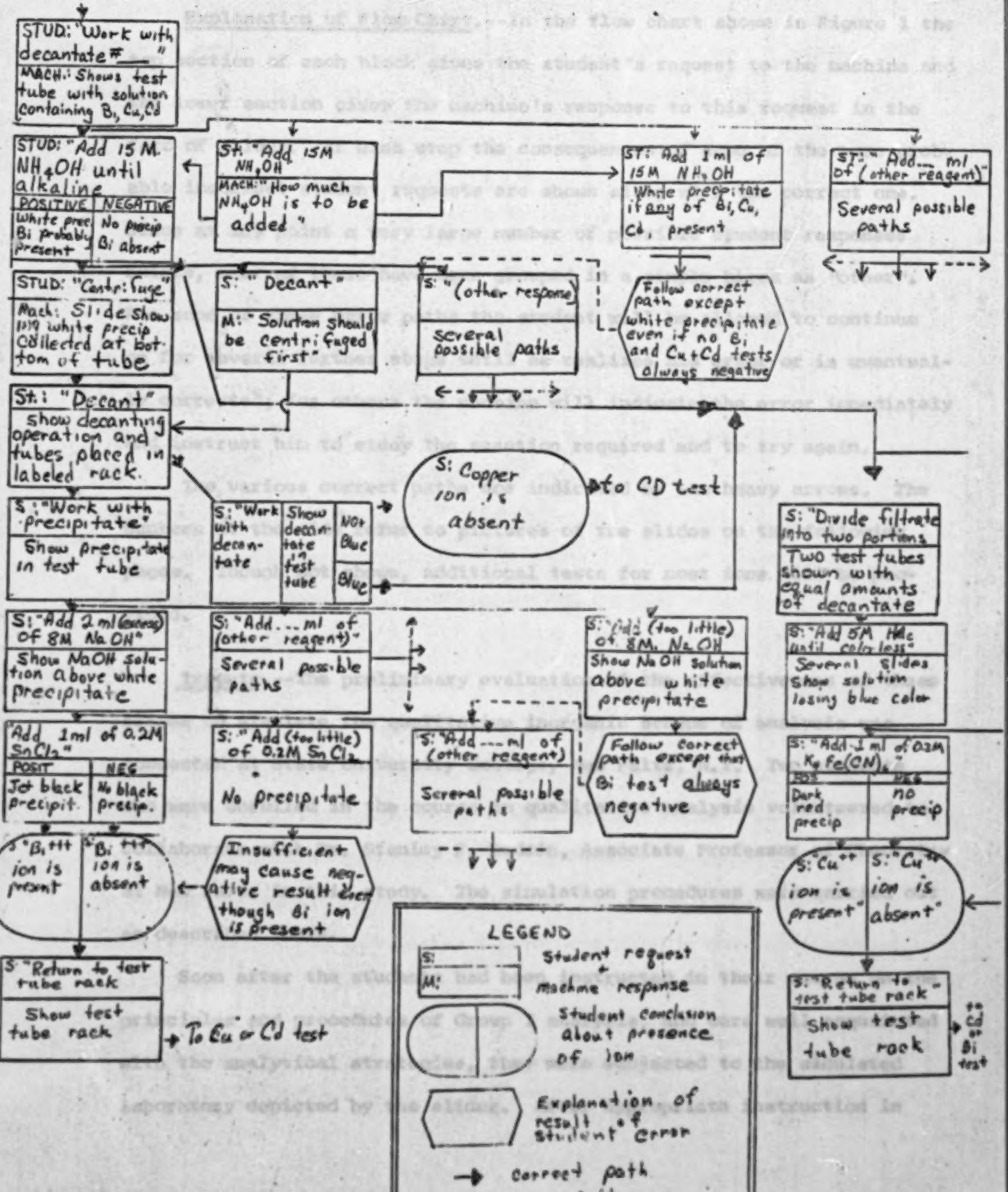
Sample procedure.--The actual working of the simulation is best explained by showing in some detail how a short section of the analysis proceeds. The following sequence is taken from the middle of the system of analysis and covers the identification of only two ions, bismuth and copper. It illustrates the complicated branching necessary even in such a small segment of the analysis. (See Figure 1)

At the start the student has just finished determining the presence or absence of the ion immediately preceding bismuth in the scheme and now requests to return to the test tube rack which holds, among others, the decantate which may contain ions of bismuth, copper and cadmium. These three ions may be present in any combination or even be entirely absent; this the student must determine. He then types in a series of instructions to the computer.

Figure 1

FLOW CHART

Copper Bismuth-Area


STUD: "Work with decantate #__"
MACH.: Shows test tube with solution containing Bi, Cu, Cd
STUD: "Add 15 M NH4OH until alkaline"
POSITIVE: White precip Bi probably present
NEGATIVE: No precip Bi absent
St: "Add 15M NH4OH"
MACH: "How much NH4OH is to be added"
ST: Add 1 ml of 15M NH4OH
White precipitate if any of Bi, Cu, Cd present
ST: "Add ... ml of (other reagent)"
Several possible paths
STUD: "Centrifuge"
Mach: Slide showing white precip collected at bottom of tube
S: "Decant"
M: "Solution should be centrifuged first"
S: "(other response)"
Several possible paths
Follow correct path except white precipitate even if no Bi and Cu+Cd tests always negative
St: "Decant"
Show decanting operation and tubes placed in labeled rack.
S: Copper ion is absent
to CD test
S: "Work with precipitate"
Show precipitate in test tube
S: "Work with decantate"
Show decantate in test tube
Not Blue
Blue
S: "Divide filtrate into two portions"
Two test tubes shown with equal amounts of decantate
S: "Add 2 ml (excess) of 8M NaOH"
Show NaOH solution above white precipitate
S: "Add ... ml of (other reagent)"
Several possible paths
S: Add (too little) of 8M NaOH
Show NaOH solution above white precipitate
S: "Add 5M HAc until colorless"
Several slides show solution losing blue color
Add 1 ml of 0.2M SnCl2
POSIT: Jet black precipit.
NEG: No black precip.
S: "Add (too little) of 0.2M SnCl2"
No precipitate
S: "Add ... ml of (other reagent)"
Several possible paths
Follow correct path except that Bi test always negative
S: "Add 1 ml of 0.2M K4Fe(CN)6"
POS: Dark red precip
NEG: no precip
S: "Bi+++ ion is present"
S: "Bi+++ ion is absent"
Insufficient may cause negative result even though Bi ion is present
S: "Cu++ ion is present"
S: "Cu++ ion is absent"
S: "Return to test tube rack"
Show test tube rack
To Cu or Cd test
S: "Return to test tube rack"
Show test tube rack
to Cd or Bi test
LEGEND
S:
M:
Student request
machine response
Student conclusion about presence of ion
Explanation of result of student error
correct path

Explanation of Flow Chart.--In the flow chart shown in Figure 1 the top section of each block gives the student's request to the machine and the lower section gives the machine's response to this request in the form of slides. At each step the consequences of some of the more probable incorrect student requests are shown along with the correct one. Since at any point a very large number of possible student responses exists, most of these have been grouped in a single block as "other". For some of these error paths the student will be allowed to continue on for several further steps until he realizes his error or is eventually corrected; for others the machine will indicate the error immediately and instruct him to study the reaction required and to try again.

The various correct paths are indicated by the heavy arrows. The numbers at the side refer to pictures of the slides on the following pages. Though not shown, additional tests for most ions will be provided.

Tryouts.--The preliminary evaluation of the effectiveness of these slides to simulate the qualitative inorganic scheme of analysis was conducted at State University College, New Paltz, N.Y. Two students who were enrolled in the course in qualitative analysis volunteered to collaborate with Dr. Stanley F. Kudzin, Associate Professor of Chemistry at New Paltz in this study. The simulation procedures were carried out as described above.

Soon after the students had been instructed in their course on the principles and procedures of Group I analysis, and were well acquainted with the analytical strategies, they were subjected to the simulated laboratory depicted by the slides. After appropriate instruction in

Group II, a second session in the simulated laboratory was held. Each session began with a complete analysis of all the cations found in that group. In Group I, these were silver, mercurous, and lead; in Group II, mercuric, lead, copper, bismuth, cadmium, tin, arsenic and antimony were determined. Each student was then given an unknown solution for analysis which was projected onto the screen by the appropriate slide.

To carry out his analysis, the student was presented with a list of laboratory operations and chemical reagents which were pertinent to the complete scheme of analysis. He would then inform the instructor of the operation (and reagent) that he wished to perform on (and add to) the solution. The instructor would then project the appropriate slide depicting the result of the student's instruction. The student would then again select an operation and reagent for the next step in the analysis and this would be projected onto the screen by the instructor. In this manner, a complete analysis of the unknown solution was simulated.

The two students proceeded through the analysis without undue difficulty. Group II is a more complex group and so it was more difficult for the instructor to manipulate the trays of slides and to perform the simulated storage function. Otherwise the tests worked fairly well.

No controlled comparisons were made between the experimental subjects and any others since the purpose of the tryouts was only to test the practicability of simulating a laboratory with a simulated control system.

Conclusions.--

1. The potential value of such simulation of laboratory procedures

lies in the exposure to a variety of analytical problems to each of which the student may apply his knowledge of the basic scheme of analysis in considerably less time than that required for actual laboratory analysis.

2. This method of instruction tested the student's memorization of the scheme of analysis. It did not add much to his understanding of the basic chemistry upon which the scheme depends.

3. The slides depict the results of operations performed precisely and accurately. They do not simulate student performance but rather an expert's. The student's performance under these conditions will not necessarily parallel his laboratory performance.

4. To provide independent practice opportunities for a large number of students in the application of the qualitative inorganic scheme of analysis, this method of simulation would be of enhanced value if properly programed into a computer. The manual method of testing just described would become extremely tedious and of questionable effectiveness when applied to the simulated analysis of all cations of the five groups comprising the scheme of analysis usually covered in a course in qualitative inorganic analysis.

ELECTRONICS

About a month's time was spent on a short project to explore electronics as a subject for simulation.[1]

The problem within electronics selected for exploration was the design of an audio amplifier as an exercise for advanced students of electronics. The simulation consisted of displaying tube characteristics graphically making it possible for the student to try different component values and signal inputs on a function generator feeding two oscilloscopes in order to observe immediately the amount of amplification and other results, such as distortion and frequency effects, produced by the combination of inputs.

Objectives.--The experimental purpose was to find out whether it was possible to design an array of electronic equipment not computer-based which would permit an electronics student to simulate tube characteristics in the manner described. From this experience some inferences were to be drawn concerning the feasibility of designing a computer-based array for a similar purpose.

The educational objective was to design a learning situation which would

1. Constitute a design exercise that could relate all of the prior learning to a practical problem in electronics,

2. Make it possible for the student to engage in the project without consuming materials.

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[1] The researcher on this project was William McNally, then an electronics instructor at the Northern Westchester Technology and Education Center.

3. Provide for the student to engage in the exercise with immediate and private supervision, unlike the situation in regular classrooms,

4. Make the design exercise flexible so that no stylized, forced design resulted, and

5. Make the design techniques dynamic, so that trial and error methods could be employed.

Related Research.--The only similar project we know of is that of Huggins at Johns Hopkins. (See Part I).

Hypothesis.--That the simulation of the design for an audio amplifier would enable a student to gain experience in component selection, circuit arrangement, and testing of the completed device without the time consumption and expense of actual fabrication.

Method.--

1. Subjects.--It was presumed that such an exercise would be useful for students who had completed the major portion of a two-year secondary school technical electronics program including DC and AC theory, vacuum tube theory, and instruction on the operation of voltage and power amplifiers. The previous training should also have included some laboratory experience in the testing of components and in the repair of audio amplifiers and radio receivers.

2. Equipment.--With the eventual use of computer-controlled equipment in mind, a transitional phase was undertaken in which the equipment consisted of two oscilloscopes linked by circuitry as shown in Figures 1 and 3 with input controls turned manually. Published data as in the RCA Tube Handbook were presumed to be available on tube resistance and capac-

itance and output transformer value. (Figure 2).

3. Procedures.--The complete design of an audio amplifier would include the type of circuit, number of tubes, type of power supply, input and output connectors, power output, possible inputs, general costs, and so forth. However, in this project the detailed design of only the input stage would be undertaken. This stage had been selected because it was the one susceptible to the most rigorous analysis without a tremendously extensive theoretic background on the part of students.

The design of the input stage would be reduced to a technique employing graphic data to describe the selected tube and using a combination of graphics and arithmetic processes to show the values of resistance, capacitance, and voltage necessary to obtain from the selected tube its optimum performance. In a display of tube characteristics, signals and voltages would be simulated and the families of curves, commonly called dynamic characteristics, would be displayed visually. In this way the student could observe a graphic representation of the effects of varying plate load resistance, plate supply voltage, and signal input; and such factors as voltage gain, distortion, and frequency effects could be dramatically presented to the student as he changed any of the parameters. In fact by selecting different parameters in a trial and error process he could optimize the design experimentally in support of his theoretic analysis and test the completed device by empiric data.

An illustrative case would be the analysis of a tube for the input stage of an amplifier. The student would go through these steps.

1. The student would select a tube for study and insert between the viewing screen and the half-silvered mirror a transparency showing plate characteristics ($i_p - e_p$) as shown in Figure 1.

2. He would then set the value of input voltage by turning a knob on the e_i signal generator. (Figure 3).

3. He would then turn a knob on the load line generator. This would have a dual effect;

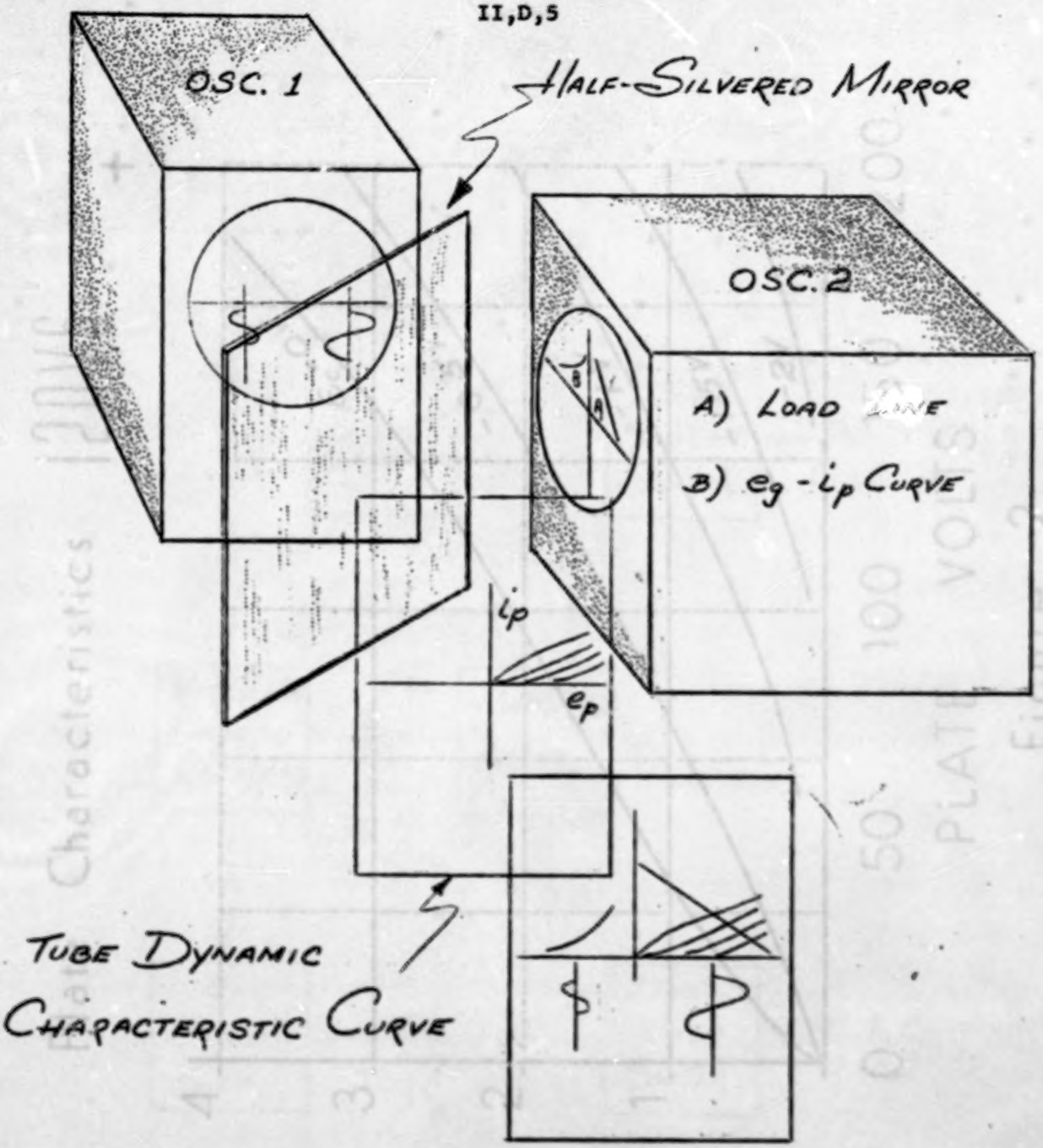
(a) The load line display would be varied on Oscilloscope #2.

(b) The output voltage display would be varied on Oscilloscope #1.

Thus the student would try to obtain an indication of sufficient voltage output to satisfy the design. If the tube, so simulated, appeared to meet the specifications originally stipulated, the student would have achieved success.

The electronics simulation was terminated without student trials and with only the rudiments of an instructional program developed. One reason was that it appeared we would not have enough students available with the prerequisite background in electronics to act as subjects for a test. Another reason for termination was that there was no immediate likelihood of obtaining the computer-based display apparatus needed. When the experiment ended, the function generator and oscilloscope were operating as described above.

Conclusions.--It was concluded from the experiment that electronics would be a suitable topic for teaching by simulation if a cathode ray tube and other terminal equipment under computer-control were available to represent the various characteristics of vacuum tubes.


OSC. 1
Half-Silvered Mirror
OSC. 2
A) Load Line
B) e_g - i_p Curve
i_p
e_p
A
B
Tube Dynamic Characteristic Curve
Viewing Screen

Method of Demonstrating Tube Design Principles —

Figure 1

Plate Characteristics 12AV6

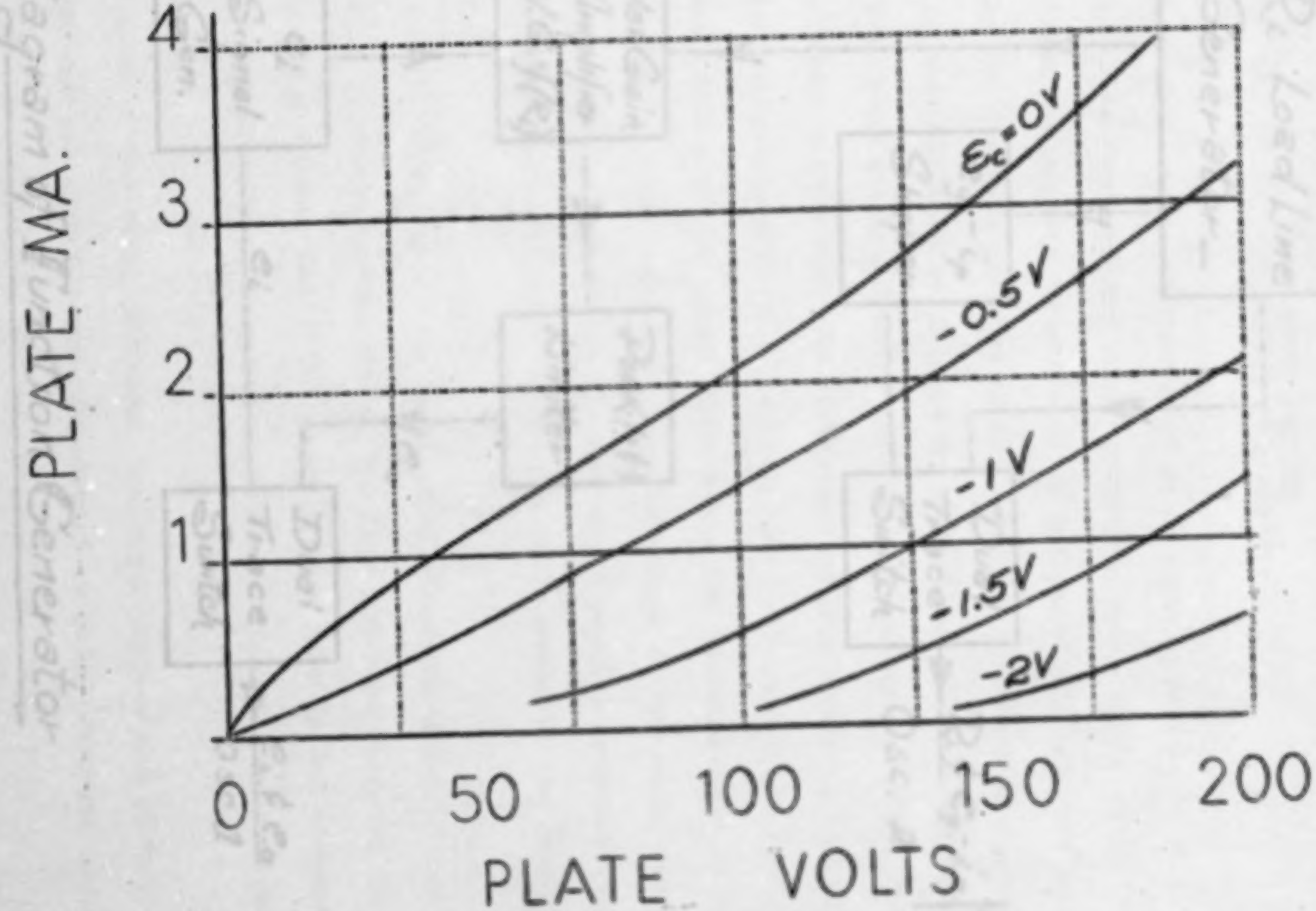


Figure 2

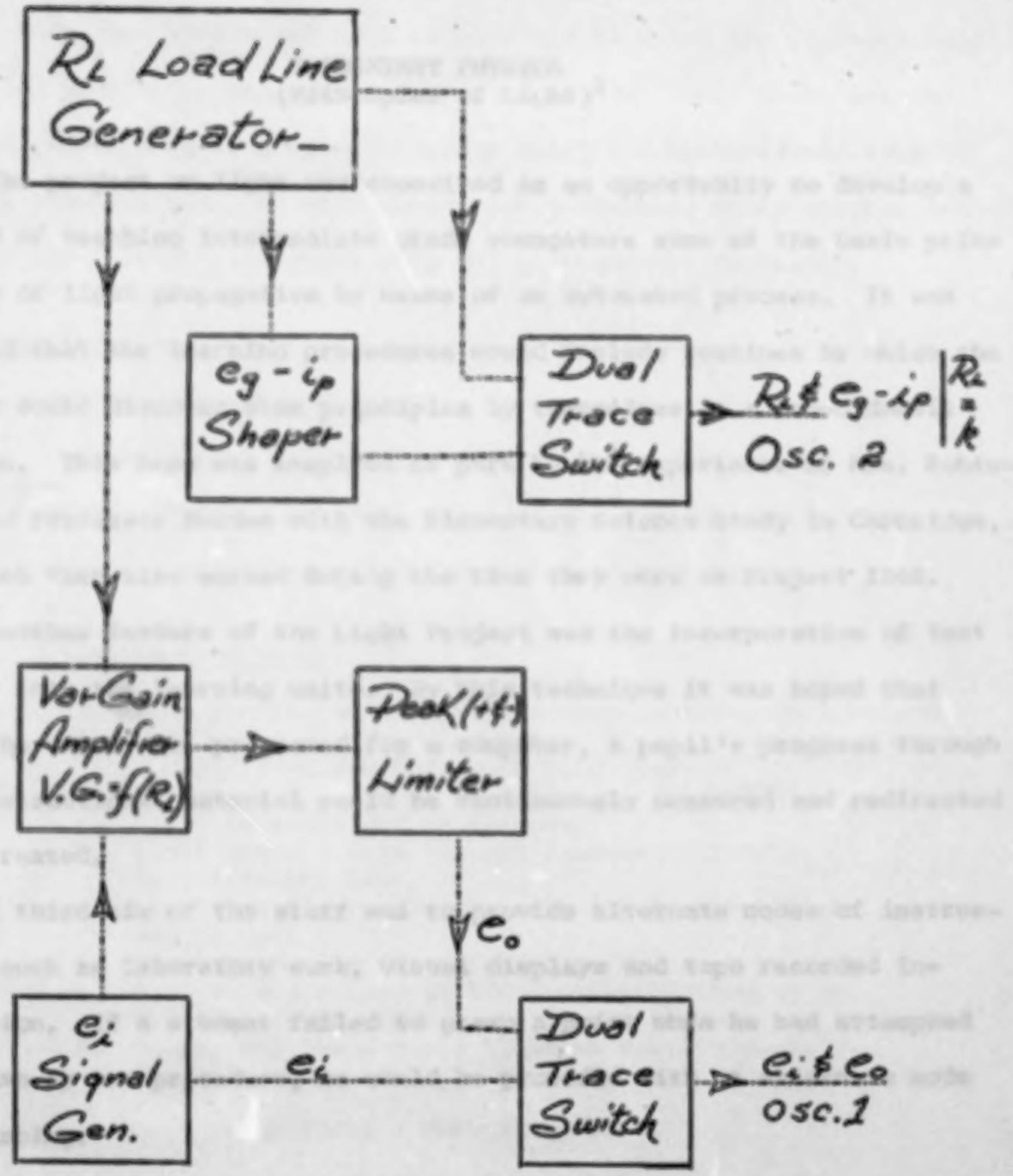

R_L Load Line Generator
$e_g - i_p$ Shaper
Dual Trace Switch
R_L & $e_g - i_p$ | $R_L = k$
Osc. 2
Var Gain Amplifier V.G. = f(R_L)
Peak (+ & -) Limiter
e_o
e_i Signal Gen.
e_i
Dual Trace Switch
e_i & e_o
Osc. 1

Diagram of Function Generator

Figure 3

ELEMENTARY PHYSICS
(Principles of Light)[1]

The project on light was conceived as an opportunity to develop a method of teaching intermediate grade youngsters some of the basic principles of light propagation by means of an automated process. It was planned that the learning procedures would include routines by which the pupils could discover some principles by themselves in a non-didactic fashion. This hope was inspired in part by the experience of Mrs. Robinson and Professor Burden with the Elementary Science Study in Cambridge, on which they also worked during the time they were on Project 1948.

Another feature of the Light Project was the incorporation of test points into the learning units. By this technique it was hoped that when the units were programed for a computer, a pupil's progress through the instructional material could be continuously measured and redirected as warranted.

A third aim of the staff was to provide alternate modes of instruction, such as laboratory work, visual displays and tape recorded instruction. If a student failed to grasp a point when he had attempted to learn by one procedure, he would be provided with an alternate mode of learning.

Like most of the other projects, the light project was planned for two stages; one was without computer control in which ordinary audiovisual aids were controlled by a teacher and in which the students used paper and pencil instead of typewriter terminals. This phase was considered preliminary to a methodology in which a computer would control student consoles equipped with typewriter terminals, audio devices, and cathode ray tube display units with the light pencil accessory.

---

[1] Mrs. Mary P. Robinson was the principal teacher-researcher on this project. During one summer she was aided by Mrs. Arthur Lee. Dr. Robert P. Burden, Professor of Applied Physics and Engineering at Harvard served as consultant for the project.

Objectives.--

1. Research objectives:

To determine whether the simulation techniques employed would provide a learning environment in which sixth grade pupils would learn certain principles about light.

2. Learning objectives:

To teach pupils the following generalizations about light.

Objectives for Unit with Flow Chart #1

a. Light is given off by the sun.
b. Light travels from the sun (source) directly, in a straight line.
c. Light travels to the eye, the eye receives light, and we see.
d. Light varies in intensity.
e. Shadows are formed by light being blocked by an object through which light cannot travel.
f. Nearly all the natural light we receive comes from the sun.

OBJECTIVES - FLOW BHART #2

a. Light travels in straight lines, under usual conditions.
b. Light travels through great distances, even through space.
c. Light travels so fast you can't see it travel.
d. The amount of light you see varies according to the intensity or strength of the source.
e. For the same intensity of light at source, the amount of light you see decreases as you are further away from the source.
f. Light from a source travels outward in all directions.

g. There are other sources of direct light.
h. Light travels in rays or beams of light which are only visible under certain conditions.

OBJECTIVES - FLOW CHART #3

a. Light travels in straight lines, usually.
b. Light is reflected when it strikes an object and bounces off.
c. The angle at which a light ray is reflected by a plane mirror is exactly the same as the angle at which it strikes the mirror. (The angle of incidence equals the angle of reflection).

A schematic representation of the learning strategy is represented in Figure 1, a Flow Chart for the third unit "Reflection". Column 1 indicates the estimated time in minutes for the student to complete that part of the unit. Column 2 lists the topic under study. Column 3 indicates alternate modes of presentation; for instance, the last topic on the page could be taught by furnishing the ESS smoke box equipment to the pupil as an alternate method to the controlled typewriter dialogue. Column 4 is a sequence showing dialogues between the computer and the student (DO) interspersed with control points (CP) which are short test sequences.

Method.--

1. Subjects:

The fifth and sixth grade classes at The Scarborough School were selected as subjects for trying out the lessons. There were several reasons for the selection of this private school: the classes were smaller, available student time was easily arranged, and there was a broad range of student ability level present in these two classes. Approximately thirty fifth and sixth grade students tried out Lesson Unit #1, and fifteen sixth grade students continued on to Lesson

Units #2 and #3. The majority of the fifth grade students found the material considerably more difficult than the sixth grade students; hence, the decision to continue with sixth grade students only. Data used for the evaluation of the tryouts were drawn from tests given to ten students: five boys and five girls, whose I.Q.'s ranged from 90 to 160.

2. Equipment:

The equipment used consisted of a tape recorder, a slide projector, and a 16 mm. movie projector. This combination should be considered as a substitute for a console with typewriter terminal, loudspeaker, and a screen for visual display - all controlled by a computer.

3. Procedures:

Mrs. Robinson was the "computer teacher" aided by Ernest Solit, the regular class teacher. She began the first lesson with these remarks.

> This is the first of our lessons in which you are being taught by a computer instead of a teacher. Imagine that you are sitting in front of a fancy desk (console) with a typewriter on it and a screen in back of it. Each console is attached to a computer a long distance away. The lesson program is typed by the typewriter onto a long roll of paper that passes through the typewriter roller as the lesson is typed. Imagine that you read the typing from the computer console and can type back each answer.
>
> Today we have no individual typewriters, individual screens for films or slides, or sounds for you alone from tape recordings. I am going to be reading the computer program to you and am asking you to write your answers on the sheet at your desk. Please answer each part of the program as you hear it. Even though you do not type your answer, please write down each answer and then do not change it. Listen and follow your computer program as carefully as possible.
>
> Remember now - I am supposed to be a typewritten

computer lesson, and since you couldn't do any talking in this kind of lesson, please remember not to talk to me. O.K.?

The computer program requires that you push in your Start Button. Push now and the program is ready to begin.

A sample of the dialogue between computer-teacher and class is given here. This section was preceded by dialogues on sources of light and properties of light.

UNIT #3
REFLECTION

PUSH START BUTTON

DP-6

Instruction:

Here we are again. Light up! Let's go over the properties of light that you have discovered so far.

Light travels in straight lines through space.

Light from a source may travel outward in all directions.

The intensity, which is the strength or amount of light you see, varies according to the intensity of its source. The amount of light you see from each source becomes less or decreases as the light from that source travels a greater distance.

Now, how did you discover that light travels through space in Flow Chart #2?

Response. (Almost any answer will be correct)

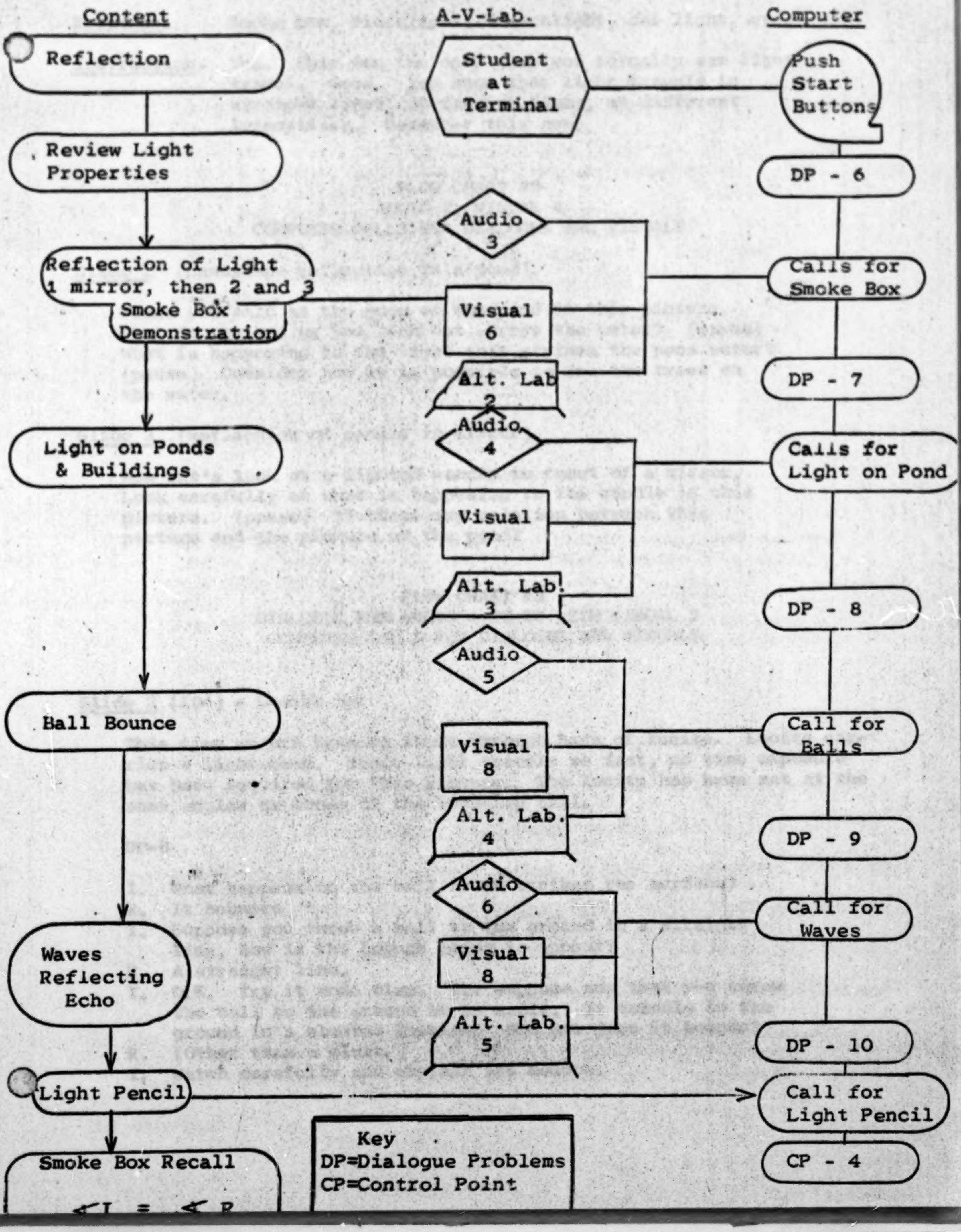
Instruction. Yes, almost anything you were learning in Flow Chart #2 indicated that light travels through space. But how did you find out that light travels in straight lines through space? Think hard on this one.

Response. (Other than light shining on particles in air where it is dark.)

Instruction. No. Which experiment actually proved to you that light travels in straight lines?

FIGURE 1

ELEMENTARY PHYSICS
#3


Content
A-V-Lab.
Computer
Reflection
Student at Terminal
Push Start Buttons
Review Light Properties
DP - 6
Audio 3
Calls for Smoke Box
Reflection of Light 1 mirror, then 2 and 3
Smoke Box Demonstration
Visual 6
Alt. Lab 2
DP - 7
Audio 4
Light on Ponds & Buildings
Calls for Light on Pond
Visual 7
Alt. Lab. 3
DP - 8
Audio 5
Ball Bounce
Visual 8
Call for Balls
Alt. Lab. 4
DP - 9
Audio 6
Call for Waves
Waves Reflecting Echo
Visual 8
Alt. Lab. 5
DP - 10
Light Pencil
Call for Light Pencil
Smoke Box Recall
$\angle I = \angle R$
CP - 4
Key
DP=Dialogue Problems
CP=Control Point

Response. Smoke box, flashlight, searchlight, car light, etc.

Instruction. Yes. This was the only time you actually saw light travel. Good. You know that light travels in straight lines, in rays or beams, at different intensities. Remember this now!

FLOW CHART #3
AUDIO 3, VISUAL 4
COMPUTER CALLS FOR DIALOGUE AND VISUALS

Slide 1 (Landscape reflection in a pond).

Place yourself at the edge of the pond in this picture. What do you see as you look out across the water? (pause) What is happening to the light that strikes the pond water? (pause) Consider how it is possible to see the trees on the water.

Slide 2 (Reflection of candle in mirror)

Now let's look at a lighted candle in front of a mirror. Look carefully at what is happening to the candle in this picture. (pause) Is there any relation between this picture and the picture of the pond?

FLOW CHART #3
DIALOGUE FOR AUDIO 4 TO GO WITH VISUAL 5
COMPUTER CALLS FOR DIALOGUE AND VISUALS

Slide 2 (104) - Lucite Set

This time we are beaming light through bars of lucite. Lucite carries a light beam. Since light travels so fast, no time exposure has been required for this picture. The lucite has been set at the same angles as those of the bouncing ball.

DP-8

I. What happens to the ball as it strikes the surface?
R. It bounces
I. Suppose you throw a ball to the ground in a straight line, how is the bounce going to appear?
R. A straight line.
I. O.K. Try it some time. But suppose now that you throw the ball to the ground at an angle. It travels to the ground in a slanted fashion. Now how does it bounce?
R. (Other than a slant.)
I. Watch carefully and explain its bounce.

R. At a slant.
I. Think of the three bouncing ball slides you just looked at. If you actually throw a ball in each of the directions that the ball is thrown in the picture, how will your ball bounce if it is hitting a nice smooth surface each time?
R. (Other than at the same angle.)
I. Think of how a ball bounces when it strikes a surface. What does the bounce look like in regard to the throw?
R. It bounces at the same angle.
I. O.K. Now what happens to light in the lucite?
R. (Other than it travels.)
I. What did you find out about what happens to light that you shine on lucite?
R. It travels.
I. As you watch the light traveling along the lucite to a surface moving away from the surface, is it traveling at the angle a ball bounces?
R. Yes.
I. Suppose now that the light was not traveling along lucite--but that you could see a beam of light traveling. You shall have a chance to observe that next.

CP-4

I. Do you agree that light traveling along lucite, such as the lucite pattern you saw, and the bounce pattern of a ball are much the same?
R. Yes.
I. How does a light ray striking a flat smooth surface look compared to a light ray after it has bounced away from the flat smooth surface?
R. Same angle.

The questions at the end of each lesson unit (CP) were designed to test the student's understanding of the objectives of the unit and in case of a lack of understanding, the student would ideally loop back to a re-run through some of the same material to have an opportunity for information retrieval or a different presentation. Since this was impossible to accomplish without the use of the computer and since the material was not presented individually to each student, this ineffective use of the control point led to the results not being recorded separately.

Each of the three lesson units took approximately thirty-five minutes to administer.

Evaluation.--The test designed for use in Elementary Physics serves as a preliminary test as well as a posttest for the unit.

The logic of the test is simple. Questions are designed to test each student's ability to reason from presumed experience about experiments or problems related to the objectives of the unit. A few questions are also included which seek to evaluate previous learning experience. An effort has been made to have the format of the test analogous to the exploration method used in the unit itself.

Since the test serves as both a pretest and posttest, no direct content from the unit is included in the test.

A sample page from the test is given in Appendix B.

The posttest was given to the ten students who completed the three lessons. Unfortunately, several students were called out of class in order to catch a bus home and were unable to finish the final posttest question; hence, the lack of notation on the velocity objective for those students who were required to leave. The time for taking the test ranged from 12-18 minutes.

Results of the testing are given in Appendix B. It may be noted that the mean number of errors dropped from 11.5 on the pretest to 6.3 on the posttest.

The ten sixth grade students whose results are indicated were the first to take the pretest. They started in on the test promptly and carefully. They had no difficulty with either the test vocabulary or the test question directions. The entire class was enthusiastic. The students agreed that they would like to spend more time on "things like this test." They said it was hard to believe it was a test. Several students said that they had new ideas they could try out either outdoors or at home. Each student agreed that the mirror reflection question was the hardest to figure out.

The general reaction of all students indicated that the test was different from any others they had taken and that they liked to have fun things to think about and figure out.

The following comments were made during pretesting:

"It gives us things to figure out."

"I can think back to things I've done or seen done."

"I like this test because I really have to do a whole lot of thinking. Thinking this way is fun and I liked it as much as everyone else. We all think it has been fun."

"I could put down my own opinions."

Conclusions concerning the effectiveness of the simulated environment mode of instruction.--After this limited experience with the simulated environment mode we can conclude from the results of the testing that the pupils increased their understanding of certain principles of light. It is also interesting to note that the total number of errors per objective also decreased in all but one instance, when there was an exceptionally low score on errors in the pretest concerning the problem dealing with shadows.

It also appeared that the pupils enjoyed learning about science when it was presented in this way. There was a great deal of attention paid to the films, slides, and tapes and this produced additional motivation toward learning the objectives for which they were searching. The interest in the new presentation was high throughout the program, including the posttest. There was, apparently, enough of a challenge within the simulated environment mode program to produce quite a high level of interest in learning.

Implications for further research.--There is little doubt that the lessons on light could be presented by means of a computer-based complex of display devices. The student responses could be typed out on a typewriter terminal such as the 1050. These responses could be analyzed by a digital computer. The visual and auditory stimuli could be presented by means of devices now in use. The programs for the typewriter could be stored on tape or disk drives. Special equipment like the light pencil could also enhance the simulation.

While there was little opportunity for individualizing instruction during the trials because of the lack of computerized equipment, it seems clear that if that were done, individuals could proceed at their own rates with differentiation in method.

The possibility of greater learning is apparent with the opportunity to branch back and learn through review by presentation of the same material in a different fashion or by a retrieval system which would allow the student to request additional information. A fully written program designed for the computer would mean far more effective instruction in the simulated environment mode.

The test data on which the conclusions are based are drawn from a small sample of pupils. Obviously a larger sample would have been desirable in order to present more meaningful results. The material used was in its original form. There are many indications of desirable changes in the dialogue problems, audio and visual presentations, and test questions.

The check point technique was not developed to the point where the results of testing were used to change the pattern of instruction. There are important implications for a system in which a frequent and accurate estimate of learning progress could be used to eliminate unnecessary procedures, to indicate alternate ways of proceeding, or to show the need for repetitions and reviews.

In view of these prospects it seems desirable to continue and expand the light project using computer-based equipment, providing branched alternatives and exploring the check point technique.

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FRENCH[1]

Background information.--Initial research for the French simulation unit was conducted from April to June 1962 with a view to determining the quantity and quality of audio-visual materials available for foreign language instruction. It was concluded that there was a paucity of motion picture and sound material dealing with subjects other than French family life and culture, and so a decision was made to innovate in the subject field of international relations for language instruction.

A script was produced for a sound motion picture simulating a visit by a French couple to a session of the Third Committee of the United Nations General Assembly. Because the Committee deals with social, cultural, and humanitarian questions, it was felt that it would furnish an excellent basis for the manipulation of a useful and varied vocabulary. A test segment of the film was made in April 1963.

Objectives.--One hope was to find out whether the United Nations simulation film could be utilized as an effective mode of individual instruction in developing conversation and comprehension skills on a sophisticated level for students who have had a minimum of three years of full-time French language study. Collateral knowledge of United Nations functions and procedures was another educational objective.

Other investigative aims were to study simulation techniques in order to make recommendations to programers concerning the extent to which electronical devices might be designed and programed to serve as the media for simulation in the teaching of French.

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[1] Researchers for the French project were Audrey I. Bratman, French and Spanish teacher at Hendrick Hudson High School, Montrose, New York, and Milo Guisti, French teacher at Yorktown High School, Yorktown Heights, New York.

Specific instructional objectives are represented by the script in Appendix C. The aim was that the students should learn the phrases and conversational structures in this script.

Transitional nature of equipment.--Like most of the subprojects described in this report the French project used a combination of audio-visual equipment which is only a crude simulation of the elaborate control and display devices which could be developed.

Visual display was accomplished by a 16 mm sound movie projector and a carousel slide projector. Sound was also provided by means of an Ampex four-track stereo tape recorder. These devices were controlled manually. It would undoubtedly be possible to invent an automatic control system for some phases of the operation, but so far this has not been done.

Procedures.--The main vehicle for presenting conversational models and opportunity for response was a film with the following content.[1]

Synopsis of Film Text

> A French couple follows the proceedings as the Chairman opens the meeting and calls upon delegates from Australia, Belgium, France, and Tunisia to discuss a report by the High Commissioner for Refugees presented at the previous session of the Third Committee. Following an explanation, made by the man to the woman, of the language facilities of the United Nations, the Belgian delegate, François Durand, takes the floor. He lauds the accomplishments in refugee camp evacuation and mental health programs and, in general, endorses the work of the Commissioner. The Australian representative,

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[1] Full text is given as Appendix C.

Mr. Hobson (heard through the voice of the French interpreter), is introduced by the Chairman.

Mr. Hobson emphasizes the satisfaction his country has derived from receiving and helping handicapped and tubercular refugees. At the conclusion of Mr. Hobson's speech, the Chairman suggests that a vote be taken to suspend the meeting for the purpose of general consultation. Meanwhile, two press representatives discuss their experiences with respect to the refugee problem. The Chairman re-opens the meeting and introduces the delegate from Tunisia, Madame Ahmed. She stresses the importance of a balanced nutritional program and a general rehabilitation effort for the Tunisian and Moroccan refugees. A polemic arises when she censures France for her limited efforts to resolve the refugee problems of the two countries. In conclusion, Madame Ahmed expresses concern for the legal status of the repatriates and notes the inadequacy of existing international instruments to solve all refugee problems. The Chairman then calls upon Madame Pagnol, the French representative, who offers a rebuttal to the Tunisian delegate. She lists concrete French contributions and concludes by affirming the importance of improving the legal status of the refugees. As the Chairman terminates the session, the man and woman discuss the refugee problem in the light of what they have just heard and decide that after lunch they will visit the Security Council.

A student could portray one of several brief roles in the film: visitor, French press representative, or chairman. The Ampex four-track stereophonic recording device permitted the elimination of any of these roles and substitution of the student's voice. Longer sections of delegates' speeches were not rehearsed by students but served only as comprehension exercises.

In order to assist students in recalling their parts of the conversation a form of cueing was introduced. A prompting device not only reminded the role-player of the fundamental thoughts and thought sequences he was being called upon to verbalize, but also afforded him ample latitude in formulating his responses.

Experiments were subsequently conducted with audio, pictorial, and simultaneous combinations, "simcom"-cues. Of these the visual prompts seemed to be more effective, so a series of precise sketches evocative of responses appropriate for the test were prepared for the Chairman's role. If the project were continued it would also be necessary to provide cues for the roles of the two French press representatives and to elaborate procedures for that portion of the script designed exclusively for the development of comprehension skills. Black/white and color sketches transferred to slides have been incorporated into the test segment of the film as an evaluation procedure.

On each of four Saturdays in April and May 1964 pairs of students from the Hendrick Hudson and Yorktown Heights schools tendered their services to the French Project. Data on sex, age, class, number of years of study, and results of Otis IQ tests were gathered for each participant. During trials role-playing responses of the subjects were recorded and analyzed.[1] There was no control group.

Two examinees present at each experimental session were guided through fifteen stages in the presentation of project materials by two teachers. Each subject received about six hours of instruction altogether.

Procedural Sequence

1. Introductory lecture on simulation
2. Written pretest
3. Specialized vocabulary and sentence structure orientation utilizing script and vocabulary lists.

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[1] See Table 1

4. Reinforcement of vocabulary and sentence structure presentation through the formation of original sentences not necessarily based upon the script.
5. Specific sentences from the text verbalized following formation of student sentences with a view of maximizing comprehension of individual key words.
6. Expansion of vocabulary and sentence structure through the formation of original sentences based upon the script.
7. Rereading of script *in extenso*.
8. Slide cue projection evoking ideas in English.
9. Slide cue projection with students expressing cue ideas in French.
10. Two viewings of version 1 and one viewing of versions 2 and 3.
11. Initial student participation in film versions 2 and 3.
12. Final student participation in the film versions 2 and 3.
13. Second viewing of film with recorded participation.
14. Written posttests A and B.
15. Round-table/tutorial student discussions on entire unit.

Results

It will be noted in Table 1 that all students did better on the posttests than the pretests. The number of cases is too small to justify elaborate statistical analysis, but it seems clear that the students were learning some of the expressions tested.

All subjects except one said they enjoyed the experience of working in this simulated mode. Participants maintained that they were helped to think quickly and logically in French and that the novel simulated environment mode combined entertainment with learning. They expressed a desire to see expanded units incorporated into the school curriculum. One slow student stated that he learned "in spite of" himself.

The facility and rapidity with which candidates succeeded in playing the roles were noted from the inception of the experiments; and, from subsequent encounters with participants, the impression was gained that knowledge acquired through exposure to the unit seemed to be of more sustained duration than information presented through standard instructional procedures.

TABLE 1

PERSONAL DATA ON SUBJECTS IN FRENCH PROJECT

Case No.	Sex	Age	Level	Years of Study	Otis IQ	Pretest	Post A	Post B
1...	M	16	Junior	Three	127	40	40	70
2...	M	16	"	"	124	90	100	100
3...	M	17	"	"	128	70	93	100
4...	M	17	"	"	128	40	77	90
5...	F	16	"	"	130	50	90	100
6...	F	16	"	"	112	30	87	80
7...	F	17	Senior	"	133	60	92	100
8...	M	16	Junior	"	106	50	50	80
Total........................					988	430	629	720
Average......................					123.5	53.75	78.625	90

Explanation of results.--The first experiments, although on a small scale have produced encouraging results. The presentation of a text with the aid of cues would not only appear to be possible but also effective, pleasant, and ultimately economical for the development of certain linguistic skills. Unlike laboratory rote learning, active participation required examinees to remain alert throughout the experience.

We conclude that the simulated environment mode is effective methodology and that the use of unit materials would entail little or no administrative modifications or problems in current study programs.

Problems and suggestions for future research.--Shortcomings in connection with certain aspects of cueing, especially with regard to the SIMCOMCUE, have been disclosed. The audio tended to confuse examinees. Exclusive pictorial cueing with the addition of a clarifying word superimposed upon the slide would appear to be a more satisfactory approach. Further cue modification with a view to decreasing the visual material on the individual slide would seem desirable. For example, a cue designed to evoke the single response HEADPHONES, and depicting visitors wearing headphones, perplexes students who wonder how much is wanted.

Obstacles were also encountered in the determination of which pictorial cue represented a concluding statement, and terminations in the middle of a sentence were not infrequent. The problem could be resolved by indicating in the lower right-hand corner of the slide--possibly by arrow or dot--the necessity for either expansion or conclusion.

While participants demonstrated during the final round of role-playing augmented comprehension of the film and a marked ability to manipulate its terminology, they could not always cope satisfactorily with the rate at which they were called upon to respond. All would prefer a stoppage device which could ultimately be controlled by the student. However, the number of times a student should be permitted to depress the recall button and when he should be permitted to do so would subsequently have to be studied.

For subsequent testing procedures in the intermediate phase of technological implementation it is recommended that the introductory lecture and presentation of materials be taped and that an explanatory slide for insertion between acts one and two be made, obviating the need for a teacher to be present.

It would also be interesting to vary the difficulty of the dialogue and the length of each speaker's conversation to see what the effects would be.

Once experiments with terminals remoted from a control center have been realized and the efficacy of the use of the simulated environment mode demonstrated, related research projects, within the frame-work of the United Nations, are suggested based on events connected with dining room, bookstore, shops, tours, informational and secretarial services, thus broadening varied terminological horizons. The new texts could either be incorporated into courses already in the curriculum or, if sufficient interest and need were established, an entire sound motion picture could be made.

Further investigation is necessary before widespread recourse to techniques alluded to can be generalized. The information gathered merely represents a modest sampling of a system the scope of which can be as vast as the energy and tenacity of its supporters.

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MUSIC PROJECT[1]

The purpose of the music project was to investigate the possible applications of a simulated environment mode of instruction to instrumental music. In the course of the experimentation with automated musical instruction three separate subprojects were begun. One of these was the attempt to teach a beginner how to assemble and play a clarinet. The second was an effort to teach a fairly well-trained clarinet player to play the Mozart Clarinet Quintet. In the third a student was taught how to interpret the clarinet part in a trio written for the project by Thomas Briccetti.

Statement of the problem.--Instrumental music education as commonly found in the schools of today includes the teaching of basic skills or techniques of playing instruments, the training of young musicians to play in a group, and guidance toward the increasingly competent and imaginative interpretation of musical notation.

Originally the instrumentalist is confronted with the problem of manipulating the instrument in order to begin to expres himself. He needs to develop a degree of technique necessary to express the primary musical thought. When the basic understanding is arrived at, there is then a freer use of the instrument as a means of satisfying the student's expressiveness. The student must place his part in the total setting of the composition, the ensemble supplying the essential harmonies written and suggested by the composer.

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[1] Dr. Donald J. Nuccio, Music Teacher at Somers High School, New York, directed this project.

The discriminating student musician must be ever conscious of improving, developing, and correcting the mechanics of manipulation and musical techniques. The degree to which he is able to approach an esthetic ideal keeps increasing as his technique changes and improves. This slowly forming ideal must always precede his capacity to realize it. A compromise is effected when he has determined his immediate technical advancement and limitations in that he accepts, for the time being, the effect produced as being adequate. In developing his overall musicianship and musical discrimination the student becomes capable of recognizing and solving technical problems confronting him in the realization of a musical work. The focus then is on the expressive content of the music rather than on the production of notes.

Music instruction in instrumental work is traditionally an individualized teaching effort. Class lessons in public school are geared to the individual student. The student's background, interest, maturation and abilities will determine the selection of music materials to be employed and intensity of instruction given in musical essentials. Effective teaching of these skills normally requires personal attention to each student on the part of skilled teachers. In order to provide learning environments for ensemble musicianship it is necessary to have a group of fairly proficient musicians. These two conditions make it difficult for a school system to provide the means for educating any sizable number of students in instrumental skills.

It was the general hypothesis of the teacher who conducted this music project that the actions of personnel normally needed to teach instrumental music could be simulated by the use of audiovisual equipment and some kind of an electronic control system.

Equipment.--The equipment used generally in the three subprojects of this experiment was an Ampex 300 series consisting of a 1/2" four-track transport and a 1/4" two-track transport with accompanying electronics units, microphone mixer, and selsync unit. For the first of the three subprojects a remote signalling device was used consisting of a box with twelve switches at the student end connected by cable to a panel with twelve signal lights on the technician's end. Also used was a carousel projector and a rear projection screen mocked-up on the view side to simulate a computer console.

Throughout the project the equipment was operated manually by a technician who could be considered to be simulating an electronic control unit.

Methodology.--The methodology for this project was based on the concept of simulation, considered in three modes. In the usual kind of musical instruction the teacher explains or demonstrates ways of playing an instrument. This straightforward exposition can be duplicated by means of slides and tape recorders. There is also a phase of instruction in which the student asks questions of the instructor. These questions have to be anticipated for purposes of the experimentation and a technique devised by which the subject can indicate at any time what his questions are. At that point it is necessary to have a repertoire of the slides and sound which will provide satisfactory answers to the subject's questions. A third and difficult kind of simulation consists in provision for evaluation of the student's performance. With the present state of technology it is not possible to obtain equipment which will automatically evaluate tone quality and musicianship in general. For this reason it is necessary to devise a technique of self-evaluation. It is at this point that the multi-track tape recorder becomes useful. By means of this device the student can listen to a model performance, record and play back his own performance, and make a comparison between his performance and that of the model.

Evaluation.--Since we know no way to measure musical performance objectively, we invited several experts to listen to tape recordings made before and after each instructional sequence. These experts included Professors Robert Pace of Teachers College, Columbia, and Walter Ihrke of the University of Connecticut. Their reactions are included in the individual reports which follow.

A. Beginning Clarinet Instruction

Objectives.--

1. To teach the student how to assemble the clarinet to insure proper alignment of the upper and lower sections without damaging the keys and rings and to put the reed in place.

2. To produce a tone on the clarinet. The control of the clarinet embouchure is the instrumentalist's first and continuing task.

3. To learn to read the five notes corresponding to the five tones that are fingered by the left hand.

Method.--

1. Subjects.--Four subjects unfamiliar with the clarinet technique tried out the experimental procedures. Two were high school girls in the second semester of their junior year. One of these girls had had previous instruction on piano; the other had had no previous instrumental music experience. A third girl was in the freshman year of high school

with previous instruction on piano and flute. The fourth, a freshman boy in high school had had limited experience in piano. This subject did not have much interest in learning the clarinet.

2. Prerequisites.--The subjects had never studied clarinet, but several were trained to some extent on other instruments, and all were supposed to have been exposed to Western Civilization's modality in music. Also, the clarinet and its sound were not unfamiliar to them.

The subjects were expected to have the ability to understand and follow instructions geared to the high school level as well as the minimum physical capability required for manipulation and control of the instrument and formation of embouchure.

3. Equipment, operators, materials.--Instructional materials available to the students consisted of slide sequences of the skills to be developed, taped instruction, model clarinet parts, ensemble (piano) tapes synchronized to the appropriate musical score, and a Strobotuner for analyzing the tone produced.

Behind the scenes a technician and the investigator simulated the computer display of materials and recording tapes. The variety of student commands to the "computer" determined the pace and direction of the instruction. No personal assistance on the part of the investigator was available during the entire course of the experiment.

4. Procedures.--Before the actual instruction began, the subjects were pretested on nomenclature, tone production on the clarinet mouthpiece alone, and on music notation given. The actual instruction consisted of a sequence of slides accompanied by a tape recording which gave dir-

ections on the assembly of a clarinet, production of tones, and fingering of the instrument. The sequence of these slides and tape narrations was carefully organized to produce success. No direct intervention or comment was made by the teacher during this instructional period; the student had the opportunity to signal a request for repetition of a slide or tape sequence and to ask for help by pointing to a simulated control panel. In this event, help was provided out of the repertory of slides and tapes already prepared for the instructional sequence. By this method the teacher and technician simulated the action of a mechanical control system.

Students were encouraged to practice on their own between instructional sessions and were requested to keep a diary. At the close of the lesson a series of pictures was taken of the student's embouchure, assembling of clarinet joints, alignment of the reed and mouthpiece, and finger positions. Taped and written posttests were also administered.

Results.--Informal tests indicated gain in students' ability to list the nomenclature of the clarinet and mouthpiece assembly. Information about notation showed marked gain from pretest.

Posttest film slides of the subjects' assembling and aligning of certain clarinet sections and placing the reed indicated in general good increase in skill ability.

Tape-recorded examples of selected bars of music showed that students learned to produce and control tones and notes covered in instruction sequences.

Two examples of tone production were recorded demonstrating subjects' ability to control embouchure after completion of run-throughs.

It was clear even to the non-musician that tone quality was reasonably good after the simulation run.

Conclusions.--By means of the simulated environment mode and with a minimum of instruction, plus few but select visual displays

1. Assembly of the clarinet sections can be taught readily,
2. Preparation of the clarinet reed and the affixing of the reed to the mouthpiece unit with acceptable adjustments can be readily taught,
3. The initiation and acceptable control of clarinet tone by a beginning instrumentalist can be taught, and
4. The mechanics of note reading (pitch) and the corresponding fingerings on the clarinet can be efficiently presented, learned, and practiced.

B. Mozart Quintet Program

In this subproject the goal was to teach intermediate students of clarinet the technical and interpretive skills needed for the performance of Mozart's Quintet in A for clarinet and strings employing the simulated environment mode.

Subjects and equipment.--The subjects were two high school students, a girl with six years of instruction on clarinet and a boy with five years of training.

The chief pieces of equipment used were the Ampex four-track tape recorder and a carousel slide projector.

The first track of the Ampex contained a prerecording of the instructor's musical directions and comments. The second track, prerecorded, presented a model of the clarinet part to be learned by the student. The third track, also prerecorded, held the string quartet part of the ensemble, performed by the Budapest String Quartet. The fourth track was then available to receive the student's performance of his own part either alone or in combination with track two, track three, or both, or in alternation, since the track was erasable.

Procedures.--The learning process began with the projection of the first page of the score on the screen. The student had the option of requesting the model clarinet rendition of this page or of attempting the part himself. From then on he could also request special instruction prepared beforehand in anticipation of certain difficulties with the score. This special instruction could consist of help with fingering, tempo, phrasing, dynamics, or breathing.

After the student had rehearsed to his satisfaction, he could request to record his part with the string quartet and then play back this version or anything he had previously recorded. Many other combinations of practicing, listening, playing back, or attending to instructions were possible.

In this manner the student learned the clarinet part for the first section of the quintet in a learning environment where the music teacher and other musicians were simulated. He thus had the advantage of personal instruction and the presence of an accompaniment by one of the world's great string quartets.

For recognition of faulty playing or of competent playing on his part he had to rely on self-discrimination, since there is no known technique for providing automated criticism of musical sounds as complex as the quintet. He would have been aided in this if it were possible to slow down a tape recording without changing sound pitch.

If the sound and slide were controlled by some automatic device such as a computer, the whole process would go more smoothly. The technical implementation did not proceed to that point, however, and the subproject was dropped after it was demonstrated to the satisfaction of the teacher-researcher that the procedures were workable.

Dr. Nuccio decided to start again with a different approach and conceived the idea of teaching a student to interpret a piece of music that was less complicated and lengthy and in an idiom less familiar. His next experiment was with the Briccetti trio.

C. The Briccetti Trio

The music of the Briccetti Trio differs from that of the Mozart Clarinet Quintet in several important ways. In the first place the trio lasts less than three minutes and yet is a complete musical unit, whereas the Mozart Clarinet Quintet is a fairly lengthy piece. In the second place the style of Mozart is familiar in a general way to anyone who has studied music, so that students beginning to learn the Mozart Clarinet Quintet have a degree of familiarity with the interpretation which interferes with the evaluation of the instructional technique. Briccetti on the other hand writes in what he calls dissonant lyricism, a style which is unique and unfamiliar. Third, the technical demands on the student are less with the trio than with the quintet.

The purpose of this unit was to find out whether an automated instructional sequence in the simulated environment mode could be used to teach interpretation of music like the Briccetti trio to advanced students of clarinet. Such an effort may be considered to be a strenuous test of automation because of the elusive quality of musical values and difficulty in defining or describing successful interpretation.

As in the preceding two units it was hypothesized that the simulation procedures incorporating the use of the multitrack tape recorder would allow the student to exercise discriminatory judgments of his own performance and for comparison of his version with that of the model or the model and ensemble.

In the typical school situation there is not adequate time for personal attention to each individual student, especially for the demanding work of coaching small ensembles. Too often musicians of the level of performance represented by the artists in the Trio are not available to help the student learn to interpret music of this sort.

Method.--The subjects for the Trio project were three boys of high school age each with five to six years of experience playing the clarinet. The arrangement of equipment is shown in FIGURE 1.

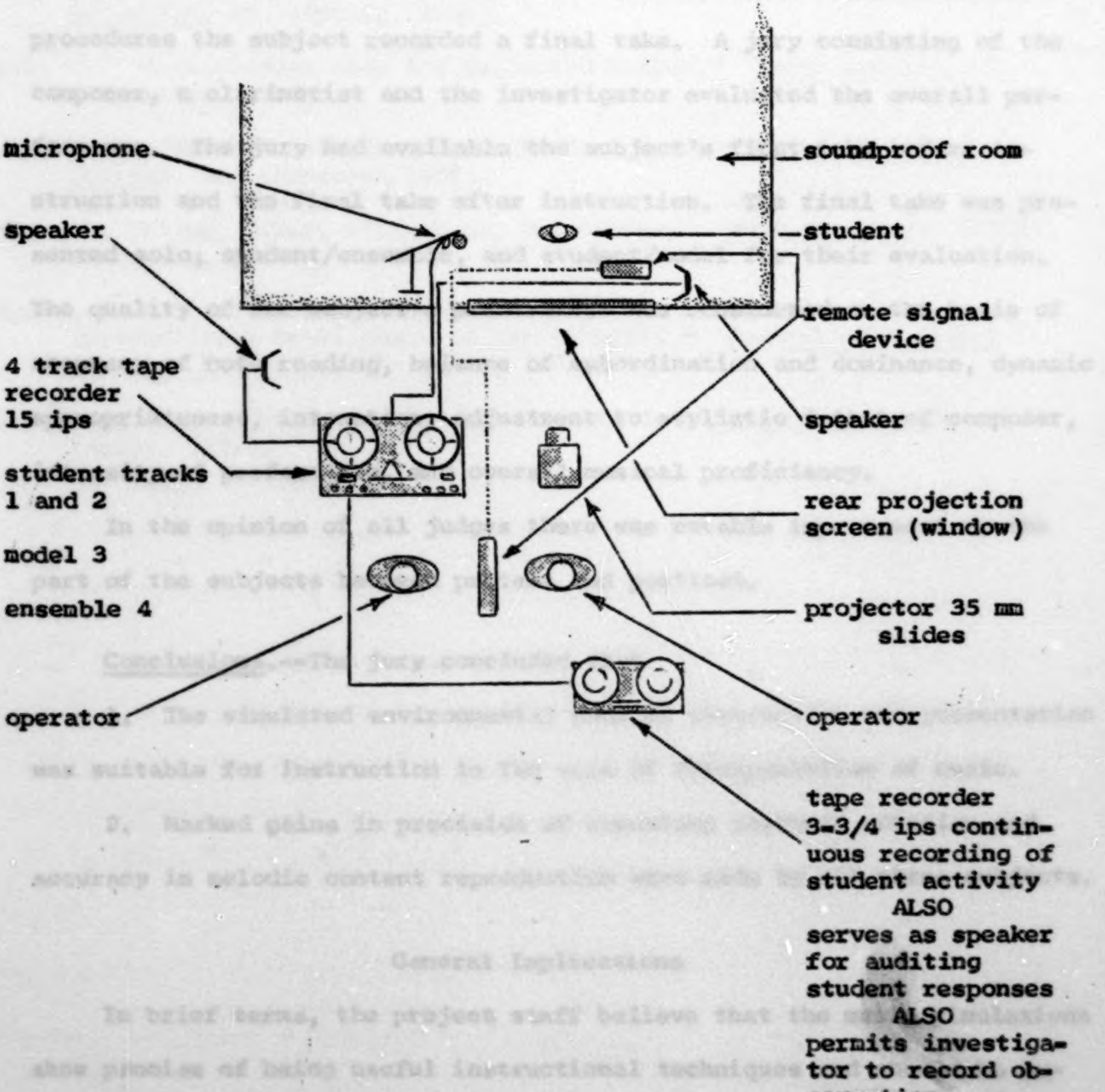
The clarinet part of the Trio was given to the subject one or two days in advance of working with the equipment. The subject was instructed to prepare the clarinet part to the best of his ability, to avoid discussing the Trio with anyone, and not to seek instruction or criticism from any sources.

At this time a tape recording was made of his reading of the clarinet part solo. Rehearsal time over a period of two-three days was provided during which the student controlled the presentation and pacing of the prepared materials. Available to him upon command was the model performance of the Trio, the ensemble part, instructions for particular phrases of the music regarding general musical information, and specific

FIGURE 1

PHYSICAL SETUP FOR EXPERIMENTAL RUN-THROUGHS

(TRIO)


microphone
soundproof room
speaker
student
remote signal device
4 track tape recorder 15 ips
speaker
student tracks 1 and 2
model 3
ensemble 4
rear projection screen (window)
projector 35 mm slides
operator
operator
tape recorder 3-3/4 ips continuous recording of student activity ALSO serves as speaker for auditing student responses ALSO permits investigator to record observation

suggestions for manipulation and interpretation. His version was recorded and could be played back either individually or in synchronization with the model and/or ensemble. Upon completion of rehearsal period the subject recorded a final take of the Trio with the ensemble.

Evaluation.--A posttest musical excerpt of similar style was presented. Within fifteen minutes of individual practice and Model/Ensemble procedures the subject recorded a final take. A jury consisting of the composer, a clarinetist and the investigator evaluated the overall performance. The jury had available the subject's first take before instruction and the final take after instruction. The final take was presented solo, student/ensemble, and student/model for their evaluation. The quality of the subject's performance was considered on the basis of accuracy of note reading, balance of subordination and dominance, dynamic appropriateness, intonation, adjustment to stylistic intent of composer, intensity of performance, and overall musical proficiency.

In the opinion of all judges there was notable improvement on the part of the subjects between pretest and posttest.

Conclusions.--The jury concluded that

1. The simulated environmental node of instruction and presentation was suitable for instruction in the area of interpretation of music.

2. Marked gains in precision of executing rhythmic notation and accuracy in melodic content reproduction were made by all three subjects.

General Implications

In brief terms, the project staff believe that the music simulations show promise of being useful instructional techniques and should be revived and continued. Further study should be made of the technology needed.

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THE SUMERIAN GAME[1]

Rationale.--The idea of constructing a computer model of the ancient Sumerian civilization which could be used for teaching basic economics came from Bruse Moncreiff of IBM, who in turn was inspired by Rousseau and Dewey, a paper by Richard L. Meier entitled "Teaching through Participation in Micro-simulations of Social Organization," by the parlor game of Monopoly, and by other experiences with simulation and gaming.

The immediate reason for the choice of the Sumerians, as stated by Moncreiff himself, was "to protect against the growing tendency in school curricula to ignore the pre-Greek civilizations in spite of the growing weight of scholarly evidence as to the important role which this pre-history and early history should play in our understanding of the processes by which our society has come to be what it is. Childe and others have identified the development of settled farming - the domestication of food plants and animals - as a necessary forerunner of urban, civilized, social organization. This transformation first occurred in lasting form in the river valleys of Mesopotamia, Egypt, and India. It is ironic that as scholarship was discovering the importance of understanding this technological, economic and social revolution, school authorities were dropping the topic from the social studies curriculum."[2]

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[1] Mrs. Mabel Addis, fourth grade teacher at the Katonah Elementary School, conducted this project.

[2] These excerpts are from Bruse Moncreiff's article in Programed Instruction, Vol. IV, No. 3 (Feb. 1965), pp. 10, 11.

How the game should work is described here in the words of its inventor.

"The student assumes the role of a priest-king of a Sumerian City-State of the late fourth millennium. The changing factors in the environment are represented by information typed out on a typewriter terminal controlled by the computer program. The general situation is presented to the student by a narrative with pictorials. The idea of an agricultural cycle of planting and harvesting is introduced. The initial problem of how much grain to set aside for the next planting is posed. The student, by trial and error, will arrive at a satisfactory figure, which must correspond to the rate-of-return parameter built into the model. Each time the student enters a "planting" figure, the model computes a "food-supply" position at the end of the following harvest.

"A constant planting figure that adequately feeds the people will not stabilize the model, since the population will tend to grow. The young priest-king must alter his estimates. Within the limits of the technology of the times, grain can be stored only for relatively short periods. Rotting and destruction by rodents will take place. But there are natural and man-made catastrophes which must be prepared for by some storage of grain. These catastrophes are introduced in the form of floods, storms, field and granary fires, etc. The student soon learns how much surplus to provide in order to minimize human suffering and waste due to grain spoilage simultaneously.

"This complex problem is difficult for the student to solve, and is typical of the experiences which should be built into such a simulated environment.

"Having discovered a progression of increasing amounts of grain to be saved for seeding which appears to stabilize the model at an acceptable nourishment level, the student soon runs into further problems. The return on an increasing number of seeds planted in the same land area does not increase linearly; in fact, the return drops close to zero when seeds are planted so close that few plants can mature. So more land must be tilled. This is the first opportunity for the student to order public works projects, namely, the construction of irrigation ditches. The workers removed from primary food production affect the temporary food supply, although the work they do tends to increase food production in the long run. The model is so constructed that large scale starvation is the result of a late decision to increase the acreage. The effects of undernourishment are felt not only as a decrease in the population, but also as a lingering lowering of the production per man. One or more of such periods of starvation may so lower the vitality of the civilization it can no longer survive.

"If the student and his city-state survive these early crises, it is possible to begin building a small surplus. This can, of course, never become extensive until technological developments allow the storage of energy in a form less corruptible than that of grain. If a high level of nutrition is achieved over a substantial number of years, such technological innovations will be favored. There are other factors involved in the rate of technological developments, such as the number of people involved in the related art or craft. Our priest-king is given the opportunity to allocate people and resources to the various techniques known to exist at that period in Sumer. If he does so, and also is able to maintain a stable food supply, several inventions will be reported to him at random times, which he in turn can use or not as he sees fit. The utilization of many of these inventions will provide ways of "captializing" currently available energy in the creation of goods which can then be substituted for scarce energy in time of crisis. This is perhaps the major lesson to be learned from this exercise, and the model should be constructed in such a way as to make this point clear.

"Other possible activities for simulation in the game are the organization of social groups in Lagash, the city-state,and trade with neighboring states.......

"In summary, the objective of the game is to make decisions in such a way that the city-state survives a series of natural and political crises, that the population grows, and that a high rate of technological innovation is maintained. These goals are numerous, diffuse, and possibly conflicting, compared with typical parlor games."

The description by Moncreiff above explains the purposes and rationale of the game as originally conceived. The actual procedures worked out by Mrs. Mabel Addis, the teacher who has been composing the details of the game, have taken a form closely following Moncreiff's original plan.

Objectives.--Specific concepts have been formulated as instructional objectives for the first part of the game, the reign of Luduga I.

1. In a centrally directed economy, government officials determine what is to be produced.

2. Climate, seasons, and natural resources affect how a man provides for his basic needs.

3. There is a definite ratio between the number of bushels of grain planted and the harvest.

4. There is a limit to the time grain can be stored without spoilage; therefore, the first grain stored should be the first used.

5. It is important to create a surplus of grain because disasters may result in the loss of grain.

6. There is a limit to the amount of seed which can be planted on a given area. When that limit has been reached, the returns begin to diminish.

7. When the optimum yield on a given acreage has been reached and the population continues to increase, it is necessary to cultivate more land.

8. Technological innovations can improve productivity.

9. There is a connection between the state and structure of the economy and the number of the total population.

a. Population rises and falls with the success and failure of harvests as well as disasters.

b. As population increases, the quantity of grain planted must increase.

c. As population increases, the quantity of grain set aside for consumption must increase.

10. There is a direct relationship between the behavior of the people and the amount of food available to support a man and his family.

Hypotheses.--It was expected that during the experimentation with the Sumerian Game, operated at first without a computer, evidence would be found to show that the game was an effective style of teaching economics and that (eventually) the game could be programmed on a computer in such a way that a sixth-grade pupil of average ability could learn from it.

A further hypothesis was that by means of the computer-based game, individual pupils could proceed at their own pace through a sequence of materials which adapted itself to their learning capabilities.

Equipment.--The Sumerian Game has gone through two phases as far as instrumentation is concerned. In the first stage the teacher, simulating a computer, operated a Wollensak tape recorder and a Kodak slide projector and responded to the students orally. Later on, the initial plays of the game were programed for the IBM 7090 computer (modified) with the pupil operating an IBM 1050 typewriter terminal. No slides were shown after the introduction. The equipment and procedures described in this report will be those used in the later stages of the game when it was being converted to computer control.

Procedures.--Since the start of the research the game has been divided into three phases, each corresponding to the reign of a king of Lagash in the neighborhood of Sumer. The game has been tried out on several sixth grade pupils in the attempt to find out whether the procedures are practical and meaningful for sixth grade pupils.

During an introductory synchronized tape and slide presentation the child sees himself as a ruler's son in the city-state of Lagash in the year 3500 B.C. At the conclusion of this orientation the rules and the initial economic conditions are given to the child by means of a typewriter terminal controlled by the computer. He then assumes the role of Luduga I, priest-ruler of Lagash, and is presented with his first problematic situation: "We have harvested 5,000 bushels of grain to take care of 500 people. How much of this grain shall be set aside for the next season's planting, and how much will be stored in the warehouse? The remainder will be given to the people to eat." This problem is repeated throughout the entire game. Each harvest represents six months in the life of a ruler.

The child makes decisions and enters his answers at the computer terminal. The computer immediately returns a Progress Report, including the number of bushels of grain in the harvest reaped from the seed grain set aside for planting, a report on his inventory, crop losses from disaster, and the size of the population. A complicating figure affects the second planting. The ruler must take into account the increasing population. Eventually he is faced with the problem of expansion which entails the acquisition of new land and irrigation. At intervals the ruler is presented with technological innovations and disasters which alter his decisions.

The rule of the first Luduga is devoted to the solution of problems pertaining to an agricultural economy. In the second phase of the game, the child will be given the opportunity to apply his surplus grain to the development of crafts. In the third and final stage he will be introduced to trade and the more complex problems which confront a changing economy. The rate and trend of the development will be dependent upon the wisdom of the child's decisions.

To date about a half hour of play has been programed for the Sumerian Game on the 7090 computer.

The model.--Built into the computer program is a mathematical model in which the factors are indicated by the following parameters and equations:

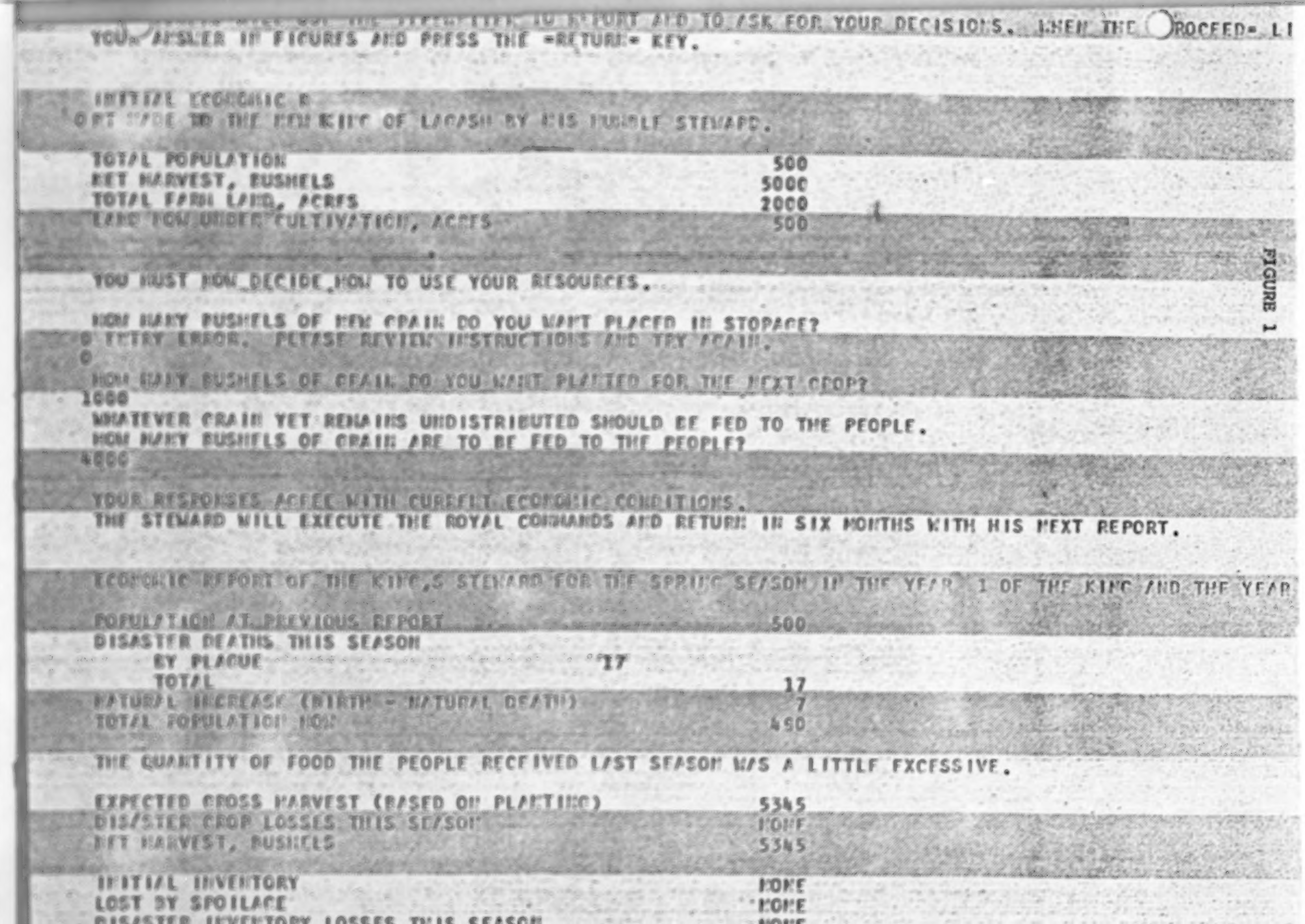
TABLE 1

Initial Parameters

Population of Lagash	500, increasing at the rate of 1% each six months
Arable land	2,000 acres
Cultivated land	700 acres
Expansion possibilities	1,300 acres
Seed needed for planting	1 acre = 2 bushels
Production	1 acre
Consumption	1 bushel/person/month
Rotting function	grain rots if stored longer than 1½ years

The model is programed so that when the student varies the amounts of grain planted, stored, and distributed to the people, the population figure is reported by the computer as varying within the limits set by the other initial parameters. A sample printout is reproduced as Figure 1.

FIGURE 1



```
TO REPORT AND TO ASK FOR YOUR DECISIONS.  WHEN THE  ROCEED= LI
  YOUR ANSWER IN FIGURES AND PRESS THE =RETURN= KEY.

  INITIAL ECONOMIC R
ORT MADE TO THE NEW KING OF LAGASH BY HIS HUMBLE STEWARD.

  TOTAL POPULATION                                    500
  NET HARVEST, BUSHELS                               5000
  TOTAL FARM LAND, ACRES                             2000
  LAND NOW UNDER CULTIVATION, ACRES                   500

  YOU MUST NOW DECIDE HOW TO USE YOUR RESOURCES.

  HOW MANY BUSHELS OF NEW GRAIN DO YOU WANT PLACED IN STORAGE?
0 ENTRY ERROR.  PLEASE REVIEW INSTRUCTIONS AND TRY AGAIN.
0
  HOW MANY BUSHELS OF GRAIN DO YOU WANT PLANTED FOR THE NEXT CROP?
1000
  WHATEVER GRAIN YET REMAINS UNDISTRIBUTED SHOULD BE FED TO THE PEOPLE.
  HOW MANY BUSHELS OF GRAIN ARE TO BE FED TO THE PEOPLE?
4000

  YOUR RESPONSES AGREE WITH CURRENT ECONOMIC CONDITIONS.
  THE STEWARD WILL EXECUTE THE ROYAL COMMANDS AND RETURN IN SIX MONTHS WITH HIS NEXT REPORT.

  ECONOMIC REPORT OF THE KING,S STEWARD FOR THE SPRING SEASON IN THE YEAR  1 OF THE KING AND THE YEAR

  POPULATION AT PREVIOUS REPORT                       500
  DISASTER DEATHS THIS SEASON
      BY PLAGUE                         17
      TOTAL                                            17
  NATURAL INCREASE (BIRTH - NATURAL DEATH)              7
  TOTAL POPULATION NOW                                490

  THE QUANTITY OF FOOD THE PEOPLE RECEIVED LAST SEASON WAS A LITTLE EXCESSIVE.

  EXPECTED GROSS HARVEST (BASED ON PLANTING)         5345
  DISASTER CROP LOSSES THIS SEASON                   NONE
  NET HARVEST, BUSHELS                               5345

  INITIAL INVENTORY                                  NONE
  LOST BY SPOILAGE                                   NONE
  DISASTER INVENTORY LOSSES THIS SEASON              NONE
```

The computer program and system.--The coding language for the Sumerian Game is Fortran Assembly Program (FAP) with a few additional control cards for file loading purposes. The program is under supervision of IBM's Time Sharing Monitor system (TSM), which has been designed for a modified IBM 7090 system. TSM will accept commands from up to twenty-four terminals at the same time. The terminals need not be in any particular geographic location, and they need not be alike. For the Sumerian Game the terminals used are IBM 1052 printers with IBM 1051 control units and are remoted from the central processing unit by telephone line through 103 Dataphones (Bell). Approximately 37,000 memory places are needed for the game.

Validation.--It has been, naturally, difficult to obtain accurate details of the life in ancient Lagash. To aid in establishing the authenticity of pictures and descriptions used in the game, the project teacher has consulted with Dr. Vaughn C. Crawford, Associate Research Curator, Ancient Near East, New York Metropolitan Museum of Art.

Evaluation.--Six elementary grade pupils were subjects for the intermediate or computerless stage of the experiment when procedures were being developed. Three were fifth graders and three sixth graders. Five out of the six were above average in intelligence. No tests were given to these pupils but some tape recordings were made which demonstrated that the procedures worked and the interest level was high.

Since the game has been programmed for the 7090 computer, six pupils have played parts of the game. The first, a boy with an I.Q. of 128, had little difficulty and improved from a score of zero on the pretest to a score of 91% on the posttest. None of the others has been tested.

All but one pupil showed interest, or even enthusiasm, in playing the game, which so far lasts only about half an hour.

Computer program worked.--In an extension of the game now being carried out under Basic Research Grant 2841 there will be a more extensive testing and evaluation program.

Conclusions.--

1. From these informal observations by the teacher and members of the project staff the inference can be made that the material and game mode are suitable for the sixth grade child of at least average ability, that is to say for students with a mental age of twelve or higher and the educational background of the sixth grade.

2. Apart from the one boy tested, who made 95% improvement from pretest to posttest, there has been little evicence so far as to the amount of learning which takes place during the game. Presumably the students are learning some principles of economics and some facts about ancient Sumer.

3. Economics models of the degree of complexity in this game can be programed for a large computer.

4. There has been considerable interest on the part of the students in working with the computer.

5. The Sumerian Game fulfills three of the conditions of variability set up as criteria for learning environments likely to aid in individualizing instructions: independence in rate of progress, variability in kind of sequence, and capability to provide appropriate responses.

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PART III

CONCLUSIONS AND IMPLICATIONS

Results

In an exploratory experiment of this kind only the most tentative results can be stated, each involving considerable interpretation.

1. The simulated environment mode was used in the development of instructional units in eight subject fields, art, biology, chemistry, electronics, elementary science, French, music, and economics.

2. The elements of the learning environment which were simulated included the behavior of teachers (lecture, dialogue, coaching and testing), a laboratory environment, environments external to the school (United Nations, sketching scenes, economic system, musical accompaniments), and conversation.

3. Teaching logics used included branching programs, tutorial logics, lecture and quiz, the game, the laboratory exercise; a coaching routine, an inquiry logic, and a language laboratory kind of self-evaluation method.

4. In each project there was evidence that the pupils were learning what they were expected to learn.

5. The technical procedures adopted in each project worked well enough so that there was no drastic interference with the learning process

6. In one project the simulation procedures were programed for the 7090 computer and tried out on sixth grade students. The program worked smoothly (Sumerian Game). In another project (chemistry) a program was written but not tried out.

7. The subjects appeared to be universally excited and interested in learning by the simulation techniques. None of the projects was long enough to enable the teachers to find out whether the enthusiasm would wear off after a while.

8. There was some evidence that the simulation technique saved instructional time.

Conclusions

The general conclusion is that the exploratory study of the simulated environment mode is promising enough to warrant further experimentation with simulation and with computer-based instruction.

By means of the simulated environment mode several of the kinds of variation in the learning situation previously described can be provided: change in pace of instruction, variability in kind of sequence, variety in presentation modes, and versatility in modifying response techniques. The other kinds of variability could be provided, especially if computer control were utilized.

Some kinds of learning experience were not attempted because of difficulties inherent in the process: appraisal of creative performance in art and music, evaluation of spoken language, editing of complex typed responses, simulation of sensory impressions other than sight and sound, spoken response in conversational sequence, and simulation of group interactions on verbal level. These problems may also be solved by further research.

On the whole present research with computer-based simulation gives promise of helping solve some of the problems of individualization.

Implications

Visitors to a project where a computer is being used often ask these questions:

1. For what subjects can the computer be used as a teaching aid?
2. Will the computer replace teachers?
3. What effects will the computer have on curriculum?
4. Won't it cost too much?
5. Will education be "dehumanized" by automation?

Some of these questions represent apprehensions which deserve hard consideration. Our reactions are given below.

Rationale for selection of topics to be programed in the simulated environment mode.--Desirable as it would be to have a formula for the selection of subjects to be programed in the simulated environment mode, such a recipe could not be devised at this stage of investigation. Some clues can be found, however, from the pilot project and other research on programed instruction.

It seems undeniable that subject matter which can be defined with precision lends itself to programing more readily than that which is amorphous, ambiguous, or subjective. Mathematics, it would seem, can be programed much more easily than art. But the problem is not quite that simple. Some linear mathematics programs have required many frames and much hard work, while there are presentations in the art field which can be quite easily automated.

Our original hypothesis was that a determination of what could or could not be programed would be made on the basis of the general subject matter, such as music, mathematics, or English. It now appears more helpful to say that each of the conventional subject fields is taught by a variety of methods, some of which are susceptible to simulation and some of which are not, by present methods. Thus wherever a lecture or demonstration is appropriate, the performance can be recorded and reproduced. Wherever discussion or the analysis of complex responses is called for, whether in art or mathematics, the simulation is more difficult. With additional research some problems, now too difficult, may be solved.

Role of the teacher.--One fear that has been expressed is that the machines will replace the teachers.

The guess of those people who worked on the simulation project is that teachers will not be replaced but rather that their roles will change. Our experience has been that a great deal of effort has gone into the production of learning materials and programs, that the technicians were very important, and that we could have used more personnel in planning the diagnostic and evaluative phases of the instruction. In any educational system where there is extensive use of automated equipment, many educators will be needed for staff positions in production, management, diagnosis and evaluation. Whenever automation is otherwise complete there will be an opportunity for skilled teachers to work with individual pupils and with small discussion groups instead of meeting with classes of conventional size.

A reasonable prediction is that through the combined activity of staff and technological aids an improved kind of education can emerge, if the staff assume somewhat changed roles.

Costs.-- Although data processing equipment is expensive, there has been a steady decline of costs in relation to services provided due to improvements in the hardware itself and to more efficient programming systems.

Technical advances in processing speed mean that more instructions can be executed for a given unit of cost. The storage cycle time of the IBM 1401 computer (11.5 microseconds) can be compared to the 1.5 microsecond cycle of the new 360/30 system of equivalent rental. The storage capacity of the newer system is twice that of its predecessor.

The improvement in cost performance is also due to the increased number of languages that can be more closely tailored to the specific problem to be solved. A recent and equally significant development in cost reduction of computer technology has been the ability to attach remotely located terminals to a centrally located computer. In this way many different simultaneous solutions can be provided to many computer users. This time-sharing feature cuts cost dramatically when each of many users is charged only for the fraction of time the computer is working just for him.

There is then the prospect that computer costs may soon be reduced to a level economical for schools.

Implications for Curriculum.--Most of the shortcomings of the present school curricula fall under one or another of these headings:

1. Rigidity in sequences of subjects
2. Omission of important subjects
3. Inclusion of unimportant subjects

4. Arbitrariness of course duration: one semester, two semesters

5. Resistance to change

Deficiencies in method have been discussed in Part I under the heading of individualization.

If the student terminal controlled by a computer becomes a commonplace, the way will become easier for alleviating some of the present ills of curriculum. Provided that there is an abundance of instructional programs available, it will be a simple matter to change the sequence or selection of topics to be offered to a student. Whether or not a subject is available will no longer depend solely upon the presence on the staff of a teacher with training in that subject. Exotic subjects can be introduced and useless ones dispensed with by a call to the program center. Courses will last long enough for the student to learn what is agreed to be desirable, rather than for a predetermined number of months corresponding to the school term.

Improvements in curriculum then, can be made if administration and teachers have the imagination to take advantage of the new technology.

Dehumanization.--The objective of analyzing the charges that automated instruction will "dehumanize" education did not receive much attention during the course of the project. A few observations can be made.

The fundamental objection on "dehumanization" grounds seems to be based on the assumption that the human teacher when present in the flesh pays attention to individual needs of her pupils by diagnosing their educational needs, providing them with personal treatments; that she supplies emotional reinforcement to learning by praising, blaming, or sympathizing with her pupils; and that the teacher inspires and motivates by showing enthusiasm and providing examples of model conduct in a way which automated instruction cannot duplicate.

One problem with this argument is that teachers do not invariably attend to, inspire, and sympathize with their pupils (some do), so that the comparison should be made with the average teacher in order to be fair to the simulator.

Another weak point in the argument is that it seems to be possible through automation to provide a great deal of personal diagnosis and instruction available in no other way. The teacher of thirty pupils cannot possibly attend to each one at each moment. In a computer-controlled instructional system, each pupil is receiving individual treatment.

A third point is that through some audiovisual devices, such as television, it is possible to bring before the pupil some of the most inspiring presences known.

Still and all it may never prove to be quite as comforting to receive a printout when you are in trouble as to have a truly sympathetic teacher pat you on the head and offer encouragement, and there are certainly some real dangers in automation for education if the control of programs is not in the hands of persons with profound understanding of educational problems.

Future Research

The experience with Project 1948 indicates that fruitful research might take these directions in the future.

1. Experimentation with computer-based games should be pursued. One such project is already being carried on as Cooperative Research Project 2841, "The Production and Evaluation of Three Computer-based Economics Games for the Third Grade."

2. Each of the other eight subprojects should be brought to the point where sufficient material is available for testing.

3. New topics should be explored to see what other kinds of simulation are possible.

4. New configurations of the simulated learning environment style should be developed.

5. Different technological instruments should be utilized, such as the random access sound drum and the light pencil.

6. New styles of teaching logics should be invented and tried out, in addition to linear, branching, and simulated environment styles.

7. Further exploration should be made of the use of auditory and visual cues to prompt constructed answers.

8. Further study should be made of the possibilities of using computer logic and storage capabilities to analyze and compare student responses.

9. Projects of some length should be completed in order to test the long term effects of automated instruction.

10. The computer industry should be encouraged to search for an improved technology which would include devices capable of voice recognition, language interpretation, olfactory simulation, tactile simulation, storage of moving picture sequences, and others.

11. Improvement should be sought in means of communication among persons engaged in simulation and computer-assisted instruction.

12. More study should be made of the diagnostic and evaluative aspects of automated instruction.

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APPENDIX A

MICROBIOLOGY SIMULATION TEST

PART I: Laboratory Procedures

DIRECTIONS: Each statement below is followed by four words or expressions lettered A--D. Choose the letter of the item that best completes the statement and write it on the separate answer sheet between appropriate parentheses.

1. A condition that will increase the growth rate of bacteria is A. dryness B. refrigeration C. warmth D. exposure to sunlight.

2. It is desired to obtain pure cultures of *Escherichia coli* bacteria. The best laboratory apparatus for this procedure is A. dry test tubes B. ordinary glass jars C. sterilizer and forceps D. petri dishes and nutrient agar.

3. Microbiologists are able to view viruses by use of A. gentian violet B. the electron microscope C. the spectroscope (colorimeter) D. high power of the optical microscope.

4. When working with raw sewage in the laboratory, the safest procedure to be followed would be to A. handle only with rubber gloves B. immerse container in chlorine solution before handling C. after handling, scrub your hands thoroughly with an antiseptic soap D. (no special handling is required.)

5. Laboratory pipets are stored in closed canisters *after* autoclaving in order to A. keep them clean B. avoid contamination of laboratory tables C. keep the pipets sterile D. implement an "experimental control".

6. After transferring microorganisms with a pipet, the pipet A. may be used for additional transfers B. should be destroyed C. needs only to be washed in hot soapy water D. should not be used again until re-sterilized.

7. A transfer hood is required for handling bacterial cultures in the laboratory in order to A. reduce possibility of contamination of cultures B. keep the temperature constant C. save valuable laboratory space D. (is not required.)

8. Pipet transfers of liquid media may be executed by either 1) the mouth and finger technique, or 2) an aircompression bulb. Procedure #2 would be preferrable if A. the withdrawn liquids were corrosive B. the student were a beginner in the use of pipets C. quantitative measurements were critical D. the liquids contain harmful microorganisms.

9. Complete sterilization of laboratory glassware can best be accomplished by which of the following procedures?
A. overnight incubation at 37° C B. scrubbing for 15 minutes with a detergent in hot water C. steam autoclaving at 15 lbs. pressure for 15 minutes D. heating in a drying oven for one hour at 100° C.

10. When samples of raw sewage are introduced to a sterile culture media such as bouillon or nutrient agar, you would expect to observe which of the following after 24 hrs. incubation?
A. no change B. the gelled media turns into a liquid C. many colonies of bacteria will have developed D. individual bacterial cells will be visible.

11. Nutrient agar plates are preferred over bouillon or nutrient broth for culturing microorganisms because
A. sterilization is not required B. isolation of individual colonies is easier on a gelled surface C. bacteria will grow more rapidly D. it will produce a broader spectrum of species of bacteria.

12. The purpose of incubation of cultured media is to
A. retard growth of microorganisms B. provide an optimum environment for development of cultures C. maintain "slave-cultures" for later use D. provide a convenient storage facility.

13. An alternate method to the use of the incubator for growing broth cultures of bacteria involves the use of which one of the following pieces of laboratory apparatus?
A. hot water bath at 45° C B. shaker-table aerator at 37° C C. laboratory refrigerator D. drying oven.

14. During the preparation of streaked nutrient agar plates, the wire transfer loop should be handled chronologically in which one of the following sequences?
A. flame, make transfer, reflame, place aside
B. make transfer, flame, place aside
C. transfer cultures without flaming.
D. immerse in alcohol, make transfer, re-immerse in alcohol, place aside.

15. The advantage to be gained through use of the hot water bath in bacteriological work is that
A. it maintains a constant temperature for handling culture media
B. it destroys only pathogenic species C. it provides optimum growing conditions D. it retards growth of cultures to be used at a later time.

16. "Lawns" of pure B. coli bacteria can be cultured most efficiently by which one of the following procedures?
A. streaking with a sterile inoculating wire loop
B. pipeting of a predetermined quantity of liquid B. coli broth
C. pour plate method of inoculation with B. coli broth
D. exposure to a sample of raw sewage.

17. Which one of the following is not required in the preparation of nutrient agar culture plates for growing bacteria?
    A. dissolving of dry nutrient agar crystals in distilled water.
    B. sterilization of media before inoculation.
    C. refrigeration at 18° C. before plating.
    D. maintenance of temperature above 45° C. before plates are poured.

18. Best assurance that lab culture media is sterile can be made only after it has been
    A. placed in the drying oven overnight at 100° C.
    B. autoclaved for 15 minutes at 15 lbs. steam pressure.
    C. autoclaved for 15 minutes at 15 lbs. steam pressure and then placed in the incubator overnight.
    D. autoclaved for 15 minutes at 15 lbs. steam pressure and then placed in the refrigerator overnight.

19. The results to be expected from the inoculation of a sterile culture place with tap water would best be described by which of the following observations?
    A. no bacterial colonies would appear.
    B. only harmless colonies of bacteria would appear.
    C. both harmless and pathogenic species of bacteria would appear.
    D. "nibble-areas" or plaques would appear.

20. Optimum procedure for pipet transfer of broth cultures of microorganisms demand that all but one of the following conditions be met:
    A. only a sterile pipet is used.
    B. the tip of the pipet should reach just below the surface of the stock sample solution being transferred.
    C. the tip of the pipet is immersed to the bottom of the broth to which the stock sample is being added.
    D. the inside of pipet should be flushed with distilled water.

21. Plated bacterial cultures are usually inverted in the incubator for which one of the following reasons?
    A. to avoid entry of air.
    B. to prevent droplets of condensed water from falling to the surface of the nutrient agar.
    C. to stack the plates more easily.
    D. to observe the colonies or plaques more readily.

22. Select the best reason for maintaining the temperature of the incubator where most bacteria cultures are grown at 37° C.
    A. many species are destroyed at temperatures above 37° C.
    B. bacteria will not reproduce at lower temperatures.
    C. 37° C. provides an optimum temperature for the growth and reproduction of desired species.
    D. it costs less to operate the incubator at 37° C.

23. All but one of the following instructions are mandatory in the handling and study of raw sewage samples; indicate the one which is not mandatory.
A. Never inoculate these culture samples inside the laboratory.
B. Keep the container stoppered at all times except during the actual transfer.
C. Avoid direct contact with these microorganisms.
D. Wash your hands thoroughly with a good antiseptic after handling the raw sewage container.

PART II: Escherichia coli Bacteria and the Effects of Bacteriophage

DIRECTIONS: Each statement below is followed by four words or expressions lettered A--D. Choose the letter of the item which best answers the statement and write it between appropriate parentheses on the answer sheet.

1. Which one of the following is involved in the production of new phage particles?
A. phage protein coat B. phage tail C. RNA of phage head
D. DNA of phage head plus host cell enzymes.

2. Why is most of our knowledge of viruses and DNA comparatively recent in origin?
A. Electron microscope is required to observe them.
B. They did not exist before the era of antibiotics.
C. Biologists were not interested in them.
D. They were thought to be harmless.

3. Viruses or phages possess the ability to
A. digest food B. carry on respiration
C. remain dormant in crystalline form
D. ingest food

4. The richest source from which to obtain inoculum for E. coli cultures would be
A. tap water B. distilled water C. raw sewage
D. normal saline solution.

5. Morphologically, bacteria are classified in all but which one of the following categories?
A. bacilli B. rickettsiae C. cocci D. spirilla

6. Bacteria cultures undergoing fission reproduce most rapidly during which time interval of incubation?
A. during the first 6 hours
B. between the 6th and 12th hours
C. between the 12th and 40th hours
D. not until after 48 hours

7. The "stationary" phase in development of bacterial cultures is the best time interval for performing physiological experiments because
   A. metabolic processes are at their peak.
   B. nutrients are available to the dividing bacteria without an excess of toxic matter.
   C. competitive factors are minimal.
   D. they have become self-perpetuating.

8. The decline in density of a given bacterial culture population can best be attributed to
   A. peak metabolism occurring B. least competition
   C. population adapting to a new environment
   D. a deficiency of nutrients and the accumulation of toxins.

9. If a nutrient agar culture plate of E. coli were inoculated with a concentrated solution of bacteriophages, which of the following observations would be most probable?
   A. No change B. Colonies would continue to reproduce and develop.. C. Plaques or holes would appear in the colonies
   D. New species of bacteria would develop.

10. Select the statement which describes a bacteriophage most accurately.
   A. It is a living protist.
   B. It is a virus particle that infects only vascular plants.
   C. It is a virus particle that causes poliomyelitis.
   D. It is a virus particle that causes lysis in bacterial cells.

11. The inoculation of a 16 hour E. coli broth culture with 2 million phage particles would result in
   A. the solution becoming more cloudy in appearance.
   B. the solution becoming nearly transparent in appearance.
   C. the solution becoming densely green in color.
   D. no noticeable change in appearance.

12. Lysis is the result of
   A. E. coli bacteria reproducing
   B. crossing two species of bacteria
   C. osmotic shock
   D. phage particles infecting, reproducing and destroying a bacterium.

13. The inoculation of an active E. coli lawn with several different types of phages could result in all but one of the following observations.
   A. No plaques would be seen.
   B. Large clear plaques develop.
   C. Small cloudy plaques develop.
   D. DNA fibers become visible under an optical microscope at 1000 magnifications.

14. The only component of a phage to enter an infected cell is the
   A. DNA fibers B. tail C. tail fibers D. protein coat of the head.

15. Evidence that E. coli bacilli have become infected will first appear on the lawn at which incubation interval?
A. 1 to 3 hours B. 4 to 7 hours C. 10 to 12 hours
D. 20 to 24 hours.

16. Select the item which most accurately describes the morphology of a bacteriophage.
A. needle shaped cylinder B. spherically shaped crystals
C. tail attached to a hexagonal head D. helical shaped thread

17. A phage particle is adsorbed by the infected host cell through the aid of
A. receptor substances from the host
B. whip-like movements of the tail
C. ionic attraction D. toxic excretions

18. Phage DNA enters an infected cell.
A. immediately following its adsorption.
B. when the cell wall secretes a digestive enzyme
C. when the tail fibers secrete a digestive enzyme
D. after lysis takes place.

19. Chemical studies reveal that phages are composed of
A. nucleic acid only B. protein only. C. DNA and protein
D. DNA and fatty acids.

20. Replication of infectious phage particles is possible in
A. dilute salt solution.
B. distilled water.
C. a specific host bacterial cell.
D. sterile egg albumen.

21. The minimum number of bacteriophage particles necessary to destroy a complete lawn of bacteria is
A. one B. 100 C. 2 million D. 5 million

22. Phage particles are able to replicate themselves
A. independently of external factors.
B. as soon as a temperature of 37° C. is established.
C. by mitotic division.
D. only when established within a specific host cell.

23. When E. coli bacilli become infected with phage particles
A. normal cell metabolism is completely disrupted
B. The cell's normal metabolic rate increases
C. no change in metabolism occurs.
D. the cells encyst and become dormant.

24. Transformation of infected bacterial cells is characterized by all but one of these changes
A. cessation of normal functions in the host cell.
B. diversion of cell components to phage replication
C. Synthesis of phage DNA and protein
D. production of host cell anti-toxins.

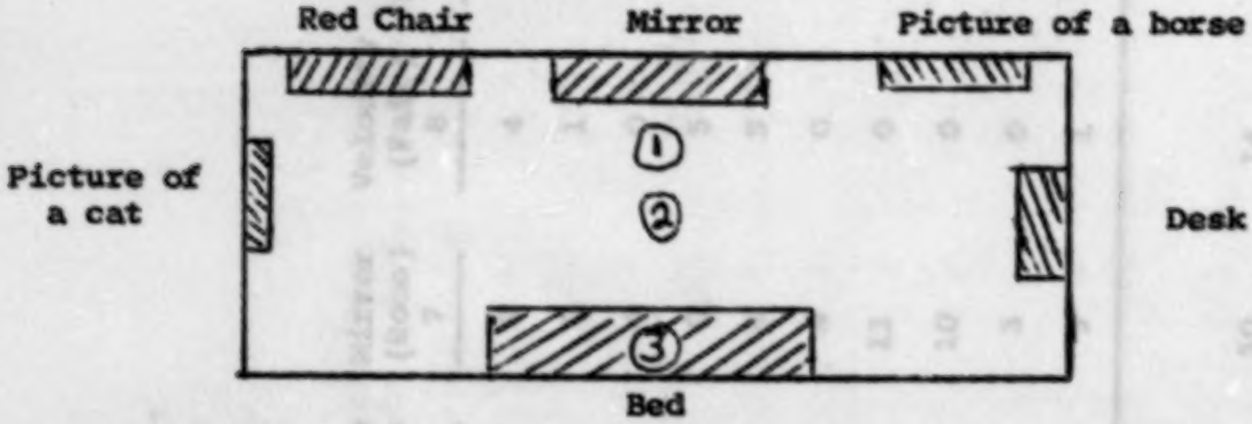
25. One of the following physiological changes is responsible for the appearance of plaques in lawns of bacteria.
A. multiple lysogeny B. single cell transformation C. protein synthesis D. secretion of enzymes

26. The best quantitative apparatus to indicate that lysis has occurred in E. coli broth cultures is the
A. optical microscope B. grid type colony counter
C. colorimeter (spectrometer) D. high speed centrifuge.

27. Microbiologists initiate osmotic shock on active virus particles in order to
A. separate them from bacteria
B. extract DNA fibers
C. increase their replication rate
D. produce mutations.

APPENDIX B

Excerpt from Test on Principles of Light


Red Chair
Mirror
Picture of a horse
Picture of a cat
Desk
①
②
③
Bed

The drawing shows a girl standing in her room facing the center of a mirror.

In Position (1), she is close to the mirror.

In Position (2), she is in the middle of the room.

In Position (3), she is across the room sitting on her bed.

Answer yes or no to each question as she looks in the mirror from each position.

	Position #1	Position #2	Position #3
a) Can she see herself?	________	________	________
b) Can she see the red chair?	________	________	________
c) Can she see the desk?	________	________	________
d) Can she see the bed?	________	________	________
e) Can she see the picture of the horse?	________	________	________
f) Can she see the picture of the cat?	________	________	________

APPENDIX B

ELEMENTARY PHYSICS

SIXTH GRADE PRETEST RESULTS

Number of Errors Per Objective

Subject	Sun & Moon 1	Intensity Sun Moon 2	Distance Sun vs Bulb 3	Speed Fast 4	Shadows (Playground) 5	Source Shadows 6	Mirror (Room) 7	Velocity (Fair) 8	Total Number Errors
R. A.	2	1	1	0	2	0	9	4	19
C. S.	2	0	1	0	0	2	0	1	6
R. D.	1	0	1	1	0	2	4	0	9
P. G.	1	2	1	1	0	0	0	5	10
J. W.	2	1	1	1	0	0	4	3	12
T. W.	1	1	1	0	0	0	4	0	7
R. S.	1	0	1	1	1	1	11	0	16
A. L.	2	1	1	1	0	0	10	0	15
T. K.	2	2	1	0	0	0	3	0	8
A. B.	2	0	1	0	0	2	5	1	11
Total Errors Per Objective	16	8	10	5	3	7	50	14	115

Mean Score = 11.5 errors

APPENDIX B

ELEMENTARY PHYSICS

SIXTH GRADE POSTTEST RESULTS

Number of Errors Per Objective

Subject	Sun & Moon 1	Intensity Sun Moon 2	Distance Sun vs Bulb 3	Speed Fast 4	Shadows (Playground) 5	Source Shadows 6	Mirror (Room) 7	Velocity (Fair) 8	Total Number Errors
R. A.	0	0	1	0	0	1	-	-	2
C. S.	0	0	0	0	0	2	0	-	2
R. D.	0	1	1	2	0	0	1	0	5
P. G.	0	1	1	0	1	1	10	2	16
J. W.	2	0	1	0	0	1	1(inc.)	-	5
T. W.	0	1	1	0	0	1	2	2	7
R. S.	2	0	0	0	2	2	0	0	6
A. L.	0	0	1	1	0	2	7	-	11
T. K.	0	0	0	0	0	1	1	0	2
A. B.	0	0	0	0	0	0	7	0	7
Total Errors Per Objective	4	3	6	3	3	11	29	4	63

Mean Number of Errors = 6.3

APPENDIX C

SCRIPT FOR FRENCH FILM

Lui: Voici un exemplaire du Journal des Nations Unies qu'on m'a donné au bureau des renseignements. Vous verrez qu'à la tête de l'ordre du jour se trouve un rapport du Haut Commissaire pour les réfugiés dont la commission est saisie.

Ces écouteurs sont à la disposition des visiteurs pour qu'ils puissent suivre le débat dans plusieurs langues.

Elle: Quelles sont les cinq langues officielles de l'Assemblée Générale?

Lui: Dans le Réglement Intérieur de l'Assemblée Générale que j'ai acheté à la librairie des Nations Unies, j'ai lu que l'anglais, le chinois, l'espagnol, le français, et le russe sont les langues officielles de l'Assemblée Générale, de ses commissions, et de ses sous-commissions.

Elle: Mais il n'y a que trois langues de travail, n'est-ce pas?

Lui: Oui, l'anglais, l'espagnol, et le français sont les langues de travail. Les discours prononcés dans l'une des langues de travail sont interprétés dans les deux autres; les discours prononcés en chinois ou en russe sont interprétés dans les trois langues de travail.

Elle: Qu'est-ce qui se passe si un représentant prend la parole dans une langue autre que les langues officielles?

Lui: Dans ce cas, il assure l'interprétation dans l'une des langues de travail.

Elle: Le Journal que vous venez de me passer est en anglais et en français.

Lui: Oui, il est publié dans les langues de travail.

Elle: Et pour d'autres documents importants, quelles langues utilise-t-on?

Lui: Toutes les résolutions et autres documents importants sont communiqués dans les langues officielles.

Elle: Les membres de la commission sont en train de prendre leurs places. Le président se prépare à ouvrir la séance.

Le Président: La 999e séance de la troisième commission de l'Assemblée Générale est ouverte. Je souhaite la bienvenue au représentant du nouvel état membre qui vient d'être admis à l'Organisation des Nations Unies et j'invite le délegué distingué de la Belgique à poursuivre le débat, conformément a l'ordre du jour, sur le rapport du Haut Commissionaire des Nations Unies pour les réfugiés. Il importe d'aborder le problème des réfugiés sous un angle purement social et humanitaire, et c'est précisément pour cette raison que la tâche a été confiée à la 3ème commission.

M. François Durand (Belgique): Parmi les réalisations du Haut Commissaire se trouve les progrès réalisés dans l'exécution du programme d'évacuation des camps et l'importance croissante accordée a la santé mentale des réfugiés. Les camps, ou la vie est extrêmement nuisible du point de vue psychologique, n'étaient qu'une solution de pis-aller. Comme bien des gouvernements, celui de la Belgique souhaite que la convention relative au statut des réfugiés entre en vigueur dans un nombre de plus en plus grand de pays. Le gouvernement belge appuie pleinement les initiatives du Haut Commissaire en faveur des réfugiés.

Le Président: Je donne la parole au délégué distingué de l'Australie.

L'Interprète: Le gouvernement de l'Australie relève avec satisfaction l'augmentation du nombre des réfugiés handicapés qui ont été autorisés a immigrer et remercie tout spécialement le Brésil, le Canada, et la Nouvelle Zélande, qui ont joué un rôle particulièrement important à cet égard. L'exemple de l'Australie montre que recevoir des réfugiés handicapés est une expérience aussi satisfaisante du point de vue des intéressés que de celui du pays d'accueil. Entre 1950 et 1959, plus de 1,000 réfugiés tuberculeux ont été admis en Australie. Après avoir suivi un traitement d'une durée moyenne de trois mois et reçu une formation professionnelle, ces réfugiés ont pu commencer à travailler. Ils ont éprouvé les sentiments de confiance et d'appui dont ils ont besoin pour s'intégrer aussi rapidement que possible à la vie du pays d'accueil.

Le Président: Je propose que l'on mette aux voix la suspension de la séance pendant quelques minutes afin de donner aux délégations la possibilité de continuer à se consulter sur les informations de base contenues dans le texte du rapport dont la commission est saisie.

France-Amérique: En tant que membre de la rédaction de France-Amérique, j'ai écrit un article de fond sur la Croix Rouge et son rôle en collaboration avec le Haut Commissaire et les autorités morocaines e tunisiennes.

Le Figaro: Oui, j'ai lu l'article. C'est une analyse extrêmement poussée.

France-Amérique: J'ai observé les progrès réalisés dans le domaine du rapatriement grace aux contributions de quelques états membres des Nations Unies au num de la communauté internationale. On dit que vous avez fait partie de la mission d'enquête qui a visité des régions atteintes par le problème des réfugiés, n'est-ce pas?

Le Figaro: Exactement, mon rédacteur-en-chef, M. Chalons, m'a chargé de faire partie de la mission d'enquête dont vous venez de parler.

France-Amérique: Vous devez donc être en mesure de faire des observations.

Le Figaro: L'Assistance dont on a parlé, a comporté en particulier, l'acquisition de matériaux de construction et celle d'un grand nombre de tentes pour l'installation temporaire des réfugiés.

France-Amérique: Qu'a-t-on fait pour prévenir d'éventuelles épidémies à cause du surpeuplement inévitable?

Le Figaro: Le flux des réfugiés a été dirigé vers dix postes de contrôle et un service médical a été installé dans chaque poste afin d'effectuer le contrôle sanitaire. Mais je trouve que l'un des problèmes les plus pénibles de ces rapatriés est leur recours prolongé a la charité et l'atteinte à leur dignité.

France-Amérique: Il faut maintenant élaborer des projets visants à donner du travail à tous les réfugiés pour maintenir la santé à la fois mentale et physique.

Le Figaro: Naturellement, plusieurs problèmes épineux, qui continueront à gêner les autoritiés, existent à présent, mais je trouve que les progrès qu'on a réalisés ne sont pas négligeables.

France-Amérique: Ecoutons. Voilà le président qui prend la parole!

Le Président: La deuxième partie de la 999e séance de la troisième commission de l'Assemblée Générale est ouverte. Je donne la parole a la représentante distinguée de la Tunisie.

Mme. Ahmed (Tunisie): Les réfugiés d'Algérie, se trouvant au Maroc et en Tunisie, reçoivent maintenant du lait et une ration quotidienne de pain. Mais il reste encore fort à faire pour leur assurer un régime alimentaire équilibré. Il faut aussi s'efforcer d'assurer aux enfants l'enseignement et aux adultes le travail. La malnutrition peut être soignée, mais les maux psychologiques peuvent causer à l'individu des torts irréparables. De plus, l'enfant inadapté peut devenir un mineur délinquant, puis un adulte criminel qui sera toute sa vie une charge pour la société. La délégation tunisienne estime que la France doit accorder une assistance accrue aux réfugiés et accepter une plus grande responsabilité, car sa situation économique est prospère.

D'ailleurs, la France a promis d'envoyer sur place une équipe médicale et sociale en vue d'éviter les épidémies et de prévenir le crime. Au mécontentement de la délégation tunisienne, elle n'est pas encore parvenue à son but. Le Maroc et la Tunisie font tout ce qui est en leur pouvoir pour aider ceux qui leur ont demandé asile, mais leurs ressources sont limitées et la France a le devoir de leur apporter son concours. La délégation tunisienne note avec satisfaction des progrès enregistrés en ce qui concerne la protection internationale des réfugiés. L'adoption d'instruments internationaux ne peut suffir à resoudre tous les problèmes qui se posent dans ce domaine. Ce qu'il faut, avant tout, c'est que les réfugiés puissent bénéficier de tous les droits dont jouissent les autres citoyens.

Le President: Je donne la parole à la représentante distinguée de la France.

Mme. Pagnol (France): La délégation française félicite le Haut Commissaire de la qualité du rapport dont la Commission est saisie, mais note avec regret les observations peu délicates de la représentante distinguée d'un pays ami. En effet, le gouvernement français a pris diverses mesures spéciales pour hâter la fermeture des camps de réfugiés et a fourni à l'UNRWA de la farine de blé. Elle a versé trois millions de dollars au cours de chacune des dernières années pour entretenir pendant trois ans des écoles de formation professionnelle et a fourni des vêtements ainsi que des suppléments proteiniques aux enfants au

Maroc et en Tunisie. De plus, la question de la protection juridique des réfugiés, qui revêt une importance capitale, a retenu tout particulièrement l'attention de ma délégation. Le gouvernement français a contribué à l'élaboration de toute une série de conventions intéressant les réfugiés. L'Assemblée Générale a prié la Commission du Droit International de considérer des principes relatifs au droit d'asile. La délégation française appuiera tout projet de résolution visant à améliorer la situation juridique des réfugiés.

Le Président: Je voudrais rappeler aux délégations qui ont exprimé leur désir de prendre la parole au sujet du rapport dont nous sommes saisis, qu'elles doivent s'inscrire sur la liste des orateurs avant 16H. 30. Je remercie la commission de sa coopération et propose que l'on mette aux voix la levée de la séance.

Elle: On peut dire qu'il n'existe pas de solution permanente pour tous les réfugiés. Leurs propres erreurs ou la malchance peuvent les réduire à nouveau à la misère. Je trouve qu'il serait malavisé de faire croire à un réfugié qu'il peut compter indéfiniment sur une assistance simplement parce qu'il est un réfugié.

Lui: Je suis d'accord, et il apprendra à voler de ses propres ailes s'il s'installe dans un pays qui souffre d'une pénurie de main d'oeuvre et où ses services peuvent etre mutuellement profitables.

Elle: Et les interprètes sont formidables! Bien que je sois bilingue, je ne pourrais jamais réussir à faire ce travail. Je voudrais assister à une autre session après le déjeuner. Peut-être que le Conseil de Tutelle se réunira cet après-midi. Regardons le Journal!

Lui: Le Conseil de Tutelle ne se réunira pas cet après-midi, mais le Conseil de Sécurité sera en session à 15H.30. La question du désarmement sera à l'ordre du jour. On entendra une communication du gouvernement soviétique sur le sujet polémique de la cessation des essais nucléaires.

Elle: Bien, allons déjeuner et chercher des billets pour la session de 15H.30.